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PROFESSOR OF NATURAL HISTORY IN THE
UNIVERSITY OF ST ANDREWS

FIFTH EDITION, REVISED AND ENLARGED

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PREFACE TO THE FIRST EDITION.

The object of this work is to serve as an Introduction to the larger works by the Author upon the same subject.

The same general plan has been followed as in the 'Advanced Text-Book'—that is to say, more space has been devoted to the Invertebrate Animals than has usually been the case in Introductory works on Zoology. As a result of this, it will perhaps appear to some that comparatively scanty justice has been done to the Vertebrata. It is to be remembered, however, that the Vertebrate Animals are of no greater *zoological* value or interest than any other of the primary divisions of the Animal Kingdom; and the limits of this work peremptorily forbid the introduction of anything beyond purely scientific matter, if each sub-kingdom is to receive its proper quota of description.

The style of the work has been as entirely freed from technicalities as possible, and most of those subjects have been omitted which require a previous acquaintance with the elements of Physiology, since the work is intended to be nothing more than an Introduction to Systematic Zoology.

PREFACE TO THE FIFTH EDITION.

IN the present edition the subject-matter has been revised, and the general arrangement of certain of the larger groups of animals has been altered in accordance with the views now most generally accepted by naturalists. It has also appeared advisable to change some of the illustrations, and to add a certain number of additional engravings, which, it is hoped, will assist in the elucidation of the text.

UNITED COLLEGE, ST ANDREWS,
February 14, 1881.

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ZOOLOGY.

INTRODUCTION.

ORGANIC AND INORGANIC MATTER.—When we come to examine into the properties of the various objects which we see around us, we at once discover that there reigns amongst them a vast diversity as regards the substances of which they are composed, and the manner in which these substances are arranged. The most obvious and striking difference which we find is that some objects are what we call "alive," whilst others are "dead;" but even dead bodies differ very much amongst themselves, and some of these differences require to be clearly understood. In the first place, chemistry shows us that of the various kinds of matter composing the universe, some are only found in living beings and are formed by the vital processes of animals and plants, whereas others occur in nature independently of the action of life. Thus, such a substance as fat is not known to occur except as entering into the composition of some animal or plant; whereas other substances, such as flint, are found to exist altogether independently of living beings, and would have still existed in the world even supposing that no animals or plants had ever been created.

To the first group of substances—namely, such as are only formed by the intervention of living beings—the term "organic" is usually applied; whilst the substances which exist naturally, without their being produced by animals and plants, are termed "inorganic."

Some limitations of the above general statement must, however, be made. Thus the same substance may be at one time part of a living being and may at another time occur quite independently of vital action, without our being able to point to any change of chemical composition. Flint, for instance, occurs in the form of sandstone, quartz, and chalcedony, and in these forms is strictly "inorganic;" but at other times it may enter into or compose the skeleton of an animal or plant, and then it becomes, in one sense, "organic." Thus even great beds of rock may come under the designation "organic," when they are composed of the accumulated skeletons of the lower animals. Again, the term "organic" has at the present day been much extended in its meaning by the wonderful discoveries of chemical science. "Organic Chemistry," as it is commonly called, embraces a much wider field of investigation than would be afforded merely by those substances which enter into the composition, or have at one time entered into the composition, of living beings, and which have never yet been artificially manufactured. Besides substances like fat, sugar, albumen, and the like, which are primarily organic, and are not known except as being formed by animals and plants, there is a vast number of other substances which must be called "organic," but which do not themselves at any time enter into the actual composition of living beings. As an example of this class of substances we may take spirits of wine; and the reason why we call these substances "organic" is, that they do not occur in nature except as secondarily derived by certain chemical processes from other bodies which were originally produced by living beings. Finally, it must be borne in mind that whilst all inorganic substances are dead, the term "organic" has nothing to do with the substance being alive or dead. The substances which compose the living body are, of course, "organic," but they continue to be equally so after death, at any rate for a certain time; whilst substances like spirits of wine, though "organic," at no time enter into the composition of the living organism.

The most striking general distinction between organic and inorganic substances is, that the latter are very little liable to undergo changes of chemical composition when acted upon by external influences, whilst the reverse is the case with the former. Inorganic substances, like flint, are what is termed "stable"—that is to say, they remain what they are under all ordinary circumstances, and do not undergo any fundamental change unless acted upon by some unusually powerful external influence. On the other hand, the organic substances which actually form part of the bodies of animals and plants, are so "unstable" that they "decompose" or *decay* when they are once removed from the living body, and this decay is so easily effected that we have some difficulty in recognising the causes to which it is due. A piece of flesh, for example, decays and becomes putrid in a very short time; and no other conditions are necessary to bring this about than that air should be present, that there should be a certain moderate degree of warmth, and that a certain amount of moisture should exist. These conditions are so universally present that an organic substance such as a piece of meat is usually said to decay "of itself." We may, however, prevent or very much retard this decay by the removal of atmospheric air, by placing the substance in ice, or by drying it and expelling all the moisture. By any one of these methods meat may be preserved for an almost indefinite period without decaying.

The *reason* why the organic materials which compose the bodies of plants and animals are so liable to decay, and undergo chemical changes so readily, is partly that they always contain more or less water, and partly that their chemical composition is very complex. The *result* of the decay of organic substances is, that they are converted into inorganic substances of a much simpler chemical composition.

Living beings, therefore, are composed of complex and elaborate organic compounds, which are formed by the vital chemistry of the body out of simple inorganic substances. When the animal or plant dies, however, then the substances of which it is composed break up and resume their primitive inorganic condition. "Dust we are, and unto dust we shall return." We are thus most strictly justified in regarding our bodies, and the bodies of all animals and plants, as being merely composed of the ordinary matter of the universe in a temporarily exalted condition.

Living and Dead Bodies.—We have seen that some of the objects which we observe around us are organic and others inorganic; but there is a further and more important difference—the difference between life and death. Some external objects are alive, others are dead; and this enables us to divide the world of nature into the "animate" and the "inanimate."

The actual *nature* of "life" or "vitality" is still unknown to us, and may possibly ever remain unknown, so we need not concern ourselves with this here. What we *mean* by "life" is simply the existence of certain phenomena which some of the natural objects around us exhibit and which others are destitute of, and it is worth our while considering what these phenomena at bottom really are.

The first and grand characteristic of living beings, by which they are distinguished from all dead bodies, is that they have the power of *growth* residing in themselves, and independent of the addition of matter from the outside. A house may be said in one sense to "grow" as the builder adds stone after stone to it; but it is in a different sense that living beings grow. From the humble acorn grows the majestic oak, and the mightiest of animals may at one time have been invisible to the unassisted vision. The growth of the elephant or the oak, however, is essentially the same, and it is at the same time not only peculiar to living beings, but fundamentally different to the "growth" of a house or a crystal. The latter is effected by the mere addition of fresh material from the outside; but a living being grows and increases in size from the interior outwards, and by virtue of a special power. All living beings, namely, possess the power of taking into themselves foreign matter—matter unlike that of their own bodies—and converting this matter into substances similar to those of which their bodies are composed. An infant, for example, lives upon milk; but it grows and becomes larger by its power of converting this milk into the muscles, bones, nerves, and other tissues of which its bodily frame is composed. This is what is called "assimilation" (Lat. *assimilo*, I make like). Even after the body has ceased to increase in *size*, as in the full-grown man, the process of "assimilation" goes on, for the body is always undergoing waste and destruction, and new tissue has therefore to be continually formed out of the food which we eat. Every living being, then, whether animal or vegetable, is distinguished by the power of "assimilation," in virtue of which it manufactures living matter out of dead and foreign substances, and adds this matter to its own body.

In the second place, every living being has the power of detaching or throwing off portions of its own substance, which under suitable circumstances may be developed into the likeness of the parent. The process is sometimes direct, sometimes indirect—sometimes complex, sometimes comparatively simple; but all kinds of animals and plants are able to produce their like and perpetuate the species, and this constitutes what is known as the power of "reproduction."

In the third place, dead bodies are subject to the various physical and chemical forces of the universe, and are incapable of suspending these laws, or modifying their action, even for a limited period. Living bodies, on the contrary, though subject to the same forces, are the seat of a something in virtue of which they can override, suspend, or modify the operation of the physical and chemical forces by which dead bodies are exclusively governed. *Dead* matter is *passive*, unable to originate movement, and unable to arrest it when once originated. *Living* matter is the seat of *energy*, and is able to overcome the primary law of the *inertia* of matter. It has certain relations with the outer world other than the merely passive ones of dead matter. However humble it may be, and even if it be permanently rooted to one place, some part or other of every living body possesses the power of spontaneous and independent motion—a power possessed by nothing that is dead. In the higher animals the relations of the living body to dead nature become still further complicated, and their mastery over the physical forces becomes more and more pronounced, till in man, whose complex organisation is wielded by an undying intelligence, we have a being in whose hands the dead matter of the universe is as obedient as plastic wax.

BIOLOGY AND ZOOLOGY.—The above are the leading characters of living beings, and the study of such bodies is known by the general name of *Biology* (Gr. *bios*, life; and *logos*, discourse). Living bodies, however, may be divided into two great groups or kingdoms—the vegetable and the animal; and in like manner, Biology is divided into the two sciences of *Botany*, which treats of plants, and *Zoology* (Gr. *zoön*, animal; *logos*, discourse), which treats of animals. The term Natural History, again, is nowadays generally understood as being equivalent to Zoology alone, though originally it was applied indiscriminately to the study of all natural objects alike.

ANIMALS AND PLANTS.—All living beings, as just remarked, may be divided into the two great kingdoms of plants and animals; but it is often an extremely difficult point to decide whether a particular organism is a vegetable or an animal. The higher animals are readily separated from the higher plants by the possession of a distinct nervous system; of locomotive power, which can be voluntarily exercised; and of an internal cavity, fitted for the reception and digestion of solid food. The higher plants, on the other hand, possess no nervous system or organs of sense, are incapable of voluntary change of place, and are not provided with any definite internal cavity, their food being wholly fluid or gaseous. It is unnecessary to enter into this question further at present; but it is to be remembered that these distinctions fail us when we come to discriminate between the lower forms of animal and vegetable life, and that in this case we are compelled to fall back upon other minuter differences.

CONDITIONS OF LIFE.—Certain conditions are necessary for the manifestation of life or vitality, as, indeed, is the case with every known force. Some of these conditions, though very generally present, are not absolutely indispensable; but there is one condition which appears to be essential, and that is, that the living body must be composed of a certain material. This material forms the essential and fundamental parts of every living being, whether vegetable or animal, and it is usually known by the technical name of "protoplasm" (Gr. *protos*, first;

and *plasso*, I mould). Living beings may, and often do, contain in their bodies many other substances beside "protoplasm," but it is in this substance that vitality seems alone to be inherent; and we are consequently justified in saying that life is only found in connection with protoplasm. It is, however, still a matter of opinion whether the protoplasm of all animals and plants is precisely the same, and under any circumstances we may believe that this substance is simply the medium or vehicle through which vital force manifests itself. Using the term in its general sense, "protoplasm" is chemically of a similar nature to *albumen* or white-of-egg, and generally has the character of a jelly-like, semi-fluid, transparent material, which does not in itself exhibit any definite structure. When heated to a certain temperature, it solidifies or "coagulates," just as the white of an egg does when boiled. In its living state also, protoplasm appears invariably to have the power of movement. Thus, any little mass of living protoplasm, if free to do so, has the power of throwing out processes of its own substance, and thus of moving and changing its place. It has, also, the power of increasing in size or of maintaining its existence by "assimilating" fresh and foreign material; and it may detach portions of its own substance which may become developed into fresh masses of protoplasm.

In some cases, though protoplasm be present, there is no external and visible manifestation of life, as is the case with eggs and seeds, which exhibit what is called a "dormant" vitality. This condition may remain for a long time unchanged, until the external circumstances are altered, and then the organism passes from a state of *dormant* into one of *active* life.

As a general rule, therefore, it is necessary for certain external conditions to be present before any external vital phenomena can be manifested; and usually life itself, even in a dormant state, cannot be maintained in the absence of these conditions. Thus, the presence of atmospheric air (or rather of free oxygen) is in an ordinary way essential to active life. The higher manifestations of vitality, again, are only possible between certain limited ranges of temperature, varying from near the freezing-point to about 120° Fahr. Water, again, is an essential constituent of protoplasm in its living state, and is therefore absolutely essential to the carrying on of vital processes of all kinds. Hence the mere drying of an animal or plant will in most cases kill it outright, and will always suspend all visible vital phenomena.

Lastly, the great majority of living beings are *organised*—

that is to say, they are composed of different parts, or *organs*, which hold certain relations with one another, and which discharge different functions. It is not the case, however, that organisation is a *necessary* accompaniment of vitality, or that *all* living beings are organised. Many of the lower forms of life exhibit absolutely no visible structure, and cannot, therefore, be said to be "organised;" but they nevertheless discharge all their vital functions just as well as if they possessed special organs set apart for the performance of each. Animals, therefore, are organised, or possess structure, because they are alive; they do not live because they are organised.

CLASSIFICATION.—Classification is the arrangement of a number of dissimilar objects of any kind into larger or smaller groups, according as they exhibit more or less likeness to one another. The number of known animals is so great that it would be wholly impossible to acquire any clear knowledge of them, unless some classification or arrangement of them into groups were to be adopted. In forming such a classification, we might take some one character, such as the possession of wings, the number of legs, or the like; just as we might divide mankind into groups according to the colour of the hair, the shape of the nose, or some other trivial feature. Classifications of this kind, however, are "artificial," and do not express the real relationships of animals; hence they are now universally discarded by naturalists. The true method of forming a classification is to compare different animals with one another as regards *all* the features which they present; and in this way we obtain what is called a "natural" classification. It is to be remembered, however, that a thoroughly natural classification of animals would imply that our knowledge of all their characters was complete; and as that is not the case, no known classification can be regarded as more than approximately true.

A natural classification, then, is founded upon a comparison of different animals with one another as regards all their essential characters; and these characters are of two kinds. *Firstly*, we have to look to the laws, form, and arrangement of the *structures* of the organism. This constitutes what is called "Morphology," or the science of form and structure (from the Greek words *morphé*, shape or form; and *logos*, a discourse). *Secondly*, we have to study the vital actions performed by the living organism, and the *functions* discharged by each portion of the body. This constitutes the science of "Physiology."

MORPHOLOGY.—As we have just seen, Morphology, as a general science, deals with the mere form and structure of the organism, irrespective of *function* or *use;* but it admits of a more or less artificial division into subordinate departments. Thus, the form and structure of living beings in their fully developed condition constitutes the science of *Anatomy.* The term *Human Anatomy* is given to the morphology of man, and the term *Comparative Anatomy* is applied to the study of the structure of animals in general, as compared with one another and with man.

Morphology, again, not only deals with the organism as a fully developed whole, but is also concerned with the changes through which every living being has to pass in reaching its mature or fully-grown condition. This constitutes a special branch of the subject to which the term "*Development*" is applied.

Finally, a separate department of the subject is sometimes constituted under the name of "*Minute Anatomy,*" to designate those morphological studies which are specially concerned with the investigation of the minute or microscopic structures and tissues of which living beings are composed, apart from the grosser and more palpable features of form and structure.

PHYSIOLOGY.—In its broadest sense, Physiology may be stated to be the *science of life and vital phenomena,*—understanding by "science," knowledge methodised and reduced to its principles. In other words, Physiology deals with the *functions* exercised by living bodies, or by the various definite parts or "organs" of which most living beings are made up. *Morphology* teaches us the structure of the animated machine; *Physiology* shows us what the machine can do, and what are the use and purpose of the various parts of which the machine is composed.

The study of the functions discharged by the human organism constitutes a distinct branch of Physiology to which the name of *Human Physiology* is applied; whilst *Comparative Physiology* is concerned with the study of the vital phenomena exhibited by the lower animals.

All the vital actions of the organism—in other words, all physiological phenomena—may be roughly divided into the following three groups :—

1. *Functions of nutrition,* comprising the various functions by which the organism is enabled to live, grow, and maintain its existence as an *individual.*

2. *Functions of reproduction,* comprising those functions whereby fresh individuals are produced, and the perpetuation of the *species* is secured, whilst the original individual perishes.

3. *Functions of relation*, comprising all those functions (such as sensation and the power of voluntary movement) whereby the outer world is brought into *relation* with the organism, and the organism in turn is enabled to react upon the outer world.

The functions of nutrition and reproduction are essential to bare existence, and are sometimes spoken of collectively as the "vegetative" functions, as being common to animals and plants alike. On the other hand, the functions of relation are often spoken of as the "animal" functions, since they are most highly developed in animals. Various plants, however, are endowed with the power of movement, and exhibit sensibility equal in amount and apparently similar in kind to that manifested by many of the lower animals; so that the functions of relation, though more characteristic of animals than of plants, are not peculiar to animals.

It should also be borne in mind, that though the above grouping of the physiological functions is convenient, it is to a certain extent arbitrary, and that the groups of functions run into one another, and are most intimately connected. Thus, for example, in the higher animals, some or all of the functions of relation are secondarily functions of nutrition, and *vice versâ*, since the integrity of both groups is essential to the working of either. If the animal be deprived of the powers of vision and locomotion, it cannot obtain food; and if its nutrition be interfered with, its functions of relation will be destroyed.

HOMOLOGY AND ANALOGY.—These are two terms which are employed to express, respectively, the morphological and physiological likenesses between the organs and parts of different animals.

When we find the same morphological structure or organ in two different animals, however much altered or disguised in form, then we have to deal with a case of *homology;* the two organs are *homologous;* and the one is said to be the *homologue* of the other. And it is not in the least degree necessary that the two homologous organs should perform the same *function* or discharge the same work. On the contrary, they may be fitted for very different purposes, and it is simply necessary that they should be formed on the same fundamental plan of structure. For example, the arm of man, the fore-leg of the dog, and the wing of a bird, are constructed upon the same morphological type, and are therefore *homologous*—as will readily be seen by referring to the annexed illustration, where corresponding parts are lettered with corresponding letters. They perform, however, totally different functions, the first being an organ of prehension, the second being devoted to terrestrial progression, and the third being an organ of flight.

On the other hand, whenever we find in different animals organs fulfilling the same purpose and doing the same work, then we have to deal with a case of *analogy*—the organs are *analogous*, and the one is said to be the *analogue* of the other. In other words, those parts or organs are *analogous* which resemble one another physiologically and discharge the same *functions*, wholly irrespective of what their fundamental *structure* may be. In most cases the organs which would ordinarily be called "analogous" are such as differ from one another in structure, at the same time that they discharge the same duties. Thus the wings of a bird and the wings of an insect are analogous organs, since they are both organs of flight, and serve to sustain their possessor in the air. They are, however, in no way similar to one another except when regarded from this physiological point of view; and they differ altogether from a morphological aspect, being in no way formed on the same fundamental plan. It often happens, however, that "analogous" organs have the deeper relation to one another of being constructed upon the same morphological plan, in which case

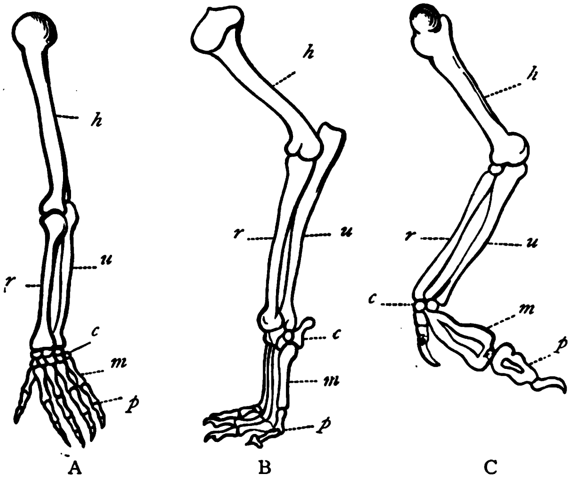

Fig. 1.—A, Arm of Man. B, Fore-leg of Dog. C, Wing of Bird. *h* Humerus, or bone of upper arm; *r* and *u* Radius and Ulna, or bones of the fore-arm; *c* Carpus, or bones of the wrist; *m* Metacarpus, or bones of the root of the hand; *p* Phalanges, or bones of the fingers.

they are *both* analogous and homologous. Thus, the leg of man and the hind-leg of a dog are both analogous and homologous, since they are constructed upon the same plan and discharge similar functions.

It need only be added in this connection that sound classification depends on a correct discrimination between likenesses of homology and likenesses of analogy. Likenesses of analogy—that is, likenesses dependent solely upon the possession of organs discharging the same physiological function—are to be disregarded. Thus, the Bird and the Butterfly are not to be grouped together simply because both possess organs of flight. On the other hand, likenesses of homology—that is to say, likenesses dependent on identity of structural plan—are a safe guide to real affinity, enabling us to trace the genuine relationships which may subsist between animals outwardly very dissimilar, and affording to us the foundation of a common type capable of almost endless modification. Whilst the *theory* of philosophical classification is thus clear, it may be further said that great difficulties attend the carrying out of the admitted theory into actual *practice*. This arises chiefly from the difficulty which is met with when we come to disentangle the homological from the merely analogical likenesses of animals; and it is in overcoming this difficulty that a great portion of the labours of the philosophical zoologist consists.

SUBDIVISIONS OF THE ANIMAL KINGDOM.—Acting upon the principles above indicated, and by a careful comparison of the morphological and physiological differences between different animals, naturalists have divided the entire animal kingdom into a number of divisions, the general arrangement of which may be very briefly indicated. Firstly, the whole animal kingdom may be divided into two great sections, known respectively as "Invertebrate Animals" or *Invertebrata*, and "Vertebrate Animals" or *Vertebrata*. The leading characters which distinguish these two great sections are exhibited in the subjoined diagram, and may be shortly stated as follows: In all invertebrate animals, the body, if divided transversely or cut in two, shows only a single tube containing all the vital organs (fig. 2, A). These organs in the higher *Invertebrata* consist of a digestive or alimentary tube; a circulatory system, by which the vital fluids are distributed through the body; and a nervous system, by which the animal is brought into relation with the outer world. Any or all of these vital organs, however, may be wanting, or may be imperfect or rudimentary. When there is any skeleton, this is usually *external*, and is mostly nothing more than a hardening of the skin, produced by the deposition in it of horny matter, of lime, or of flint. The limbs, when present, are turned towards that side of the body upon which the main portions of the nervous system are situated. In the *Vertebrata*, on the other hand, the body, if transversely divided, exhibits *two* tubes (fig. 2, B). In the one is placed the main mass of the nervous system (the brain and spinal cord). In the other tube are the alimentary canal, the main organs of the circulatory system, and certain other portions of the nervous system, which are known as the "sympathetic" system of nerves, and which correspond to the entire nervous system of Invertebrate animals. Further, in the *Vertebrata* there is always an *internal* skeleton, the central stem of which is usually constituted by a true backbone or "vertebral column." When this is not present, there is a structure which will be afterwards described as the "notochord" or "chorda dorsalis." Lastly, the limbs of Vertebrate animals, when present, are never more than four in number, and they are always turned away from that side of the body on which the main masses of the nervous system are placed.

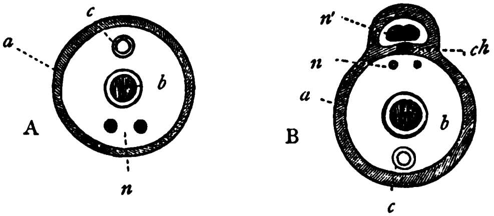

Fig. 2.—A, Diagrammatic section of one of the higher *Invertebrata*. B, Section of one of the *Vertebrata* (slightly altered from Huxley): *a* Wall of the body; *b* Alimentary canal; *c* Circulatory system; *n* Nervous system; *n'* Brain and spinal cord of the *Vertebrata*, enclosed in a separate tube; *ch* Notochord or chorda dorsalis.

The subdivision of the Invertebrate animals is divided into five great groups or "morphological types," which are known as *sub-kingdoms*. These primary types of structure are known to naturalists under the technical names of the *Protozoa*, *Cœlenterata*, *Echinodermata*, *Annulosa*, and *Mollusca*. Their distinguishing characters and more important subdivisions will be spoken of hereafter, and need not, therefore, be noticed here. The division of the Vertebrate animals constitutes by itself a sixth sub-kingdom, which is simply known under the name of *Vertebrata*. There are, therefore, *six* primary types of structure or sub-kingdoms, to one or other of which all known animals may be referred. The highest of these forms alone the division of the "Vertebrate Animals," whilst the five lower sub-kingdoms are grouped together under the collective name of "Invertebrate Animals."

Each *sub-kingdom*, therefore, comprises a group of animals which are constructed upon a common plan or type, however greatly this type may be modified; and each is, in turn, broken up into subdivisions which are termed "*classes*." Each "class," again, is divided into "*orders*," each "order" into "*families*," each "family" into "*genera*," and each "genus" into "*species*." To *define* the term "species," which is the smallest definite division accepted by naturalists, is, in the light of recent researches, no easy matter. We may, however, consider that each "species," or, as we should commonly say, "kind," of animals consists of such individuals as resemble one another in all the essential characters of their structure, and are able, directly or indirectly, to produce other fertile individuals like themselves. Even in the above definition, we must recollect that the individuals of a species are not *precisely* alike, and it commonly happens that a number of the individuals of a species have some special peculiarity or peculiarities, by which they can readily be separated from the rest. When this is the case, the individuals thus distinguishable constitute what is called a "*variety*," and if their peculiarities are permanent, and are handed down constantly by inheritance, then we get a "*race*." Thus we may suppose (though some doubt it) that all known dogs belong to and constitute one species. But we know that individual dogs, such as the greyhound, the mastiff, the terrier, the bull-dog, and the like, differ from one another so greatly that we can always recognise them with certainty. These, therefore, constitute so many *varieties* of the dog. It need only be added that the greatest of all difficulties which the practical naturalist has to confront is the difficulty of determining precisely what constitutes a *species* as distinguished from a *variety*. In other words, there are innumerable cases in which it is almost impossible to tell whether we are dealing with two closely allied species or with a species and its variety; and in no case can any definite rule of guidance be laid down by which this difficulty can be got rid of.

The classification now adopted by naturalists will, perhaps, be better understood if we take an actual example, and see how it is applied in practice. If we regard the domestic dog, with all its subordinate varieties, as a single *species*, we have to notice, in the first place, that it is known technically by a *double* name, and is called the *Canis familiaris.* All species are thus known by "binomial" designations, the *second* name being like a man's Christian name, and being distinctive of the *individual,* whilst the *first* name is like a man's surname, and indicates the *group,* or, technically, "*genus,*" to which the individual belongs. The dog, then, whilst individually recognised by the epithet "*familiaris,*" belongs to the "*genus*" *Canis,* in which are included other related species, such as the Wolf (*Canis lupus*) and the Jackal (*Canis aureus*). The genus *Canis,* again, belongs to the "*family*" *Canidæ,* including other genera, such as the Foxes (*Vulpes*). The family *Canidæ,* again, is one of a number of families, such as the Lions, Tigers, and Cats (*Felidæ*), the Bears and Racoons (*Ursidæ*), the Hyænas (*Hyænidæ*), &c., which together constitute the "*order*" of the *Carnivora* or Beasts of Prey. The *Carnivora,* again, constitute one of many orders of quadrupeds, which are distinguished by suckling their young and by other common characters, and which collectively constitute the "*class*" *Mammalia.* Finally, the class *Mammalia* is united with the classes of the Birds, Reptiles, Amphibians, and Fishes, to constitute the great primary division of *Vertebrata* or "Vertebrate Animals;" since all these classes agree with one another in the fundamental character of possessing a backbone or "vertebral column," or an equivalent structure.

Condensing the above, the zoological position of the Dog, expressed in full, would be as follows :—

Sub-kingdom, VERTEBRATA.
Class, *Mammalia.*
Order, *Carnivora.*
Family, *Canidæ.*
Genus, *Canis.*
Species, *Canis familiaris.*

In an ordinary way, however, it is quite unnecessary to employ in practice any of the above names except the last or *specific* name, since that implies all the others.

The remainder of this work will be occupied with the consideration of the chief characters of the more important groups into which the animal kingdom has been divided, omitting those which are not of paramount interest; but it will be necessary first to say a few words as to the distribution of animals in space and in time.

DISTRIBUTION IN SPACE.—The distribution of animals in *space,* or their *geographical distribution,* is a department of zoology which is concerned with determining the limits within which each species of animal is at the present day confined. Save man, and his faithful attendant the dog, no species of animal can be said to have anything like a *universal* distribution; and each species, as is a matter of common observation, belongs to a certain region, and is confined within wider or narrower limits. Thus the Giraffe, for example, is not known to exist out of Africa; the Kangaroos belong to Australia; the Armadillos do not occur out of South America,—and so on. Further than this, it is possible to divide the earth's surface into a certain number of geographical regions or "*zoological provinces*," each of which is characterised by the occurrence in it of certain associated forms of animal life. Under the head, therefore, of "distribution in space," come two different but allied branches of inquiry. Firstly, we have to inquire as to the geographical range enjoyed by each individual *species* of animal; and secondly, we have to determine what *general assemblages* of animals characterise certain large areas or provinces, and this alone demands a brief consideration here.

The geographical distribution of land animals is conditioned partly by the existence of suitable surroundings, and partly by the presence of barriers preventing migrations. Thus, certain contiguous regions might be equally suitable for the existence of the same animals, but they might belong to different zoological provinces if separated by any impassable barrier, such as a lofty chain of mountains. Owing to their power of flight, the geographical distribution of birds is much less limited than that of mammals; and many migratory birds may be said to belong to two zoological provinces. In spite of their powers of locomotion, however, birds are limited by the necessities of their life to definite areas, and a zoological province may be marked by its birds just as well as by its quadrupeds.

The geographical distribution of an animal at the present day by no means necessarily coincides with its former extension in space. Many species are known which now occupy a much more restricted area than they did formerly, owing to changes in climate, the agency of man, or other causes. Similarly, there are species whose present area is much wider than it was originally.

At the present day, naturalists usually adopt either the zoological provinces proposed by Prof. Huxley, or those proposed by Mr Sclater, both arrangements possessing certain features in common. Prof. Huxley proposes to divide the earth's surface into four primary zoological provinces, as follows, each possessing its own "fauna," or characteristic assemblage of animals:—

I. *Ornithogæa*, or the *Novo-Zelanian Province*, comprising only New Zealand.

II. *Antarctogæa*, or the *Australian Province*, comprising Australia, Tasmania, and the Negrito Islands.

III. *Dendrogæa*, or the *Austro-Columbian Province*, including South America, Central America, and Mexico.

IV. *Arctogæa*, including all the rest of the world, and having as sub-provinces,—

1. North America, north of Mexico.
2. Africa, south of the Sahara.
3. Hindostan.
4. The remainder of the Old World (Europe, Africa north of the Sahara, Asia generally, but without Hindostan, &c.)

Mr Sclater, basing his arrangement primarily on the distribution of birds, divides the earth's surface into the following six provinces:—

I. The *Palæarctic Province*, including Europe, Africa north of the Atlas Mountains, and Northern Asia.

II. The *Ethiopian Province*, including Africa south of the Atlas Mountains, and Southern Arabia.

III. The *Indian Province*, including Asia south of the Himalaya Mountains, Southern China, and the Indian Archipelago.

IV. The *Australian Province*, including Australia, Tasmania, New Guinea, New Zealand, and a large proportion of the islands of the Pacific Ocean.

V. The *Nearctic Province*, including North America down to the centre of Mexico.

VI. The *Neotropical Province*, including the whole of South America, Central America, and Southern Mexico.

Leaving the dry land, we find that even in the ocean animals are not distributed at random, but have, on the contrary, a more or less definite range. Without entering at length into this very interesting subject, two or three of the more important facts connected with the distribution of marine life may be stated here. In the first place, certain marine animals affect that portion of the sea-shore which lies between tide-marks, and are therefore more or less completely uncovered twice a-day by the retirement of the tide. Technically, naturalists call the tract between tide-marks the "Littoral Zone" (Latin, *litus*, the shore). In the second place, we find other animals which do not like to be uncovered by the retiring tide, and which live therefore just below the limit of low water, and usually extend their range till the sea becomes about fifteen fathoms in depth. Within these limits the great Tangle (*Laminaria*) flourishes in profusion, and hence this is called the "Laminarian Zone." Beyond the Laminarian Zone are other regions of different depths, which can usually be recognised more or less distinctly by the animals which inhabit them. Finally, by the researches of Carpenter, Wyville Thomson, Gwyn Jeffreys, Wallich, Sars, Pourtales, Agassiz, and other observers, we know that the "deep sea" properly so called, extending from a depth of 300 fathoms up to at least 3000 or 4000 fathoms, is tenanted by a vast number of animals, constituting a very remarkable and peculiar life-assemblage. We also know now, that, except in very limited depths, the distribution of marine animals is conditioned not by the *depth* of the water, but by its *temperature*. Similar forms of marine life are therefore found inhabiting areas in which the bottom-temperature is the same, irrespective of what the depth of the water may be. And it may happen that two neighbouring areas of the sea-bottom may be inhabited by different assemblages of animals, in spite of their being close together, provided one area is swept by a current of warm water, whilst the other has its temperature lowered by the influx of a cold current.

DISTRIBUTION IN TIME.—The distribution of animals in past time, or their "geological distribution," belongs to the science of "*Palæontology*" (Gr. *palaios*, ancient; *onta*, beings; *logos*, a discourse), and constitutes a subject so vast that nothing more can be done here than to indicate one or two of the most elementary considerations relating thereto. In the first place, Geology shows us that a very large portion of the crust of the earth is composed of rocks which existed originally in the form of sand, mud, clay, or ooze, and which formed the floor of the ocean. Other rocks can be shown to have been originally formed by lakes or rivers, and sometimes we find what may be regarded as old land-surfaces or soils. These various kinds of rock, in the second place, often contain in their interior what are called "fossils" or "petrifactions,"—in other words, the remains or traces of animals and plants which lived at the time when the rocks were in actual process of formation. In rocks which have been formed in the sea, the fossils consist chiefly of the skeletons of shell-fish, corals, sea-urchins, and other marine animals; in rocks which have been formed in lakes or rivers, we have chiefly fresh-water shells and the skeletons of fresh-water fishes; and in ancient soils we find the remains of plants, along with air-breathing animals, such as insects, spiders, or quadrupeds.

We see, then, that animals existed upon the earth for a long period before the appearance of such forms as are now familiar to us; and we have to note, in the third place, that not only are existing animals in many cases different to those which immediately preceded them, but that the globe has really passed through a succession of *periods*, during each of which there flourished an assemblage of animals more or less peculiar to the period. In the later periods of the earth's history, the animals which lived in the sea or in lakes and rivers, or which roamed upon the land or disported themselves in the air, present a general likeness to the animals now in existence, though not identically the same. In the earlier periods, again, the animals are not only "extinct," or, in other words, no longer existent, but they are very unlike any animals which we see at the present day, and the older the period the greater is this unlikeness.

We have, finally, to remember, that though many extinct animals are so peculiar that we have to place them in distinct families or orders, there is at present no known fossil which cannot be referred to one or other of the existing *sub-kingdoms*. We have therefore, so far as our present knowledge goes, no proof of the former existence and disappearance of any "morphological type."

INVERTEBRATE ANIMALS.

SUB-KINGDOM I.—PROTOZOA.

CHAPTER I.

THE sub-kingdom *Protozoa* (Gr. *protos*, first; *zoön*, animal), as the name implies, is the lowest division of the animal kingdom, and comprises a vast number of organisms, most of which are only visible to the microscope, and are therefore not familiar to the majority of people. Some few, however, such as the sponges, form colonies, which often attain a comparatively gigantic size. From their low position in the animal scale, it arises that the *Protozoa* are mainly characterised by the absence of organs and structures which occur in higher beings, and they possess few positive characters by which they can be distinguished.

All the *Protozoa* are composed of that elementary matter of life to which the name of "protoplasm" is applied. As we have already seen, protoplasm is allied in its chemical nature to white-of-egg (albumen), but in the *Protozoa* it generally possesses in addition numerous oil-globules scattered through it. In the higher animals, the protoplasm of the body usually undergoes much modification, and the organism becomes ultimately very complex in its structure. In the *Protozoa*, on the other hand, the body remains more or less unchanged, and continues throughout life to be composed of simple protoplasm, or, as it is often termed in these lowly beings, "sarcode" (Gr. *sarx*, flesh; and *eidos*, form). In fact, it very often happens that the body of the *Protozoa* exhibits no definite *organisation* or *structure*, but is composed simply of what looks to the eye like elly or thin glue, with a few floating particles in it. In other instances there are definite organs, but these are always of the simplest character.

In no case is the body of any *Protozoön* composed of a succession of more or less similar parts or "segments," as occurs in so many of the higher animals, though there is sometimes a semblance of this, owing to the existence of the peculiar power of throwing out buds. There is no nervous system, nor does the animal possess any special organs ("organs of sense") for the perception of light, sounds, smells, or the like. Some of the *Protozoa*, however, show a decided power of appreciating which side of their habitation may be illuminated, in spite of the fact that they have no eyes. Finally, the apparatus of digestion is of the simplest character, or does not exist at all in a distinct and definite form.

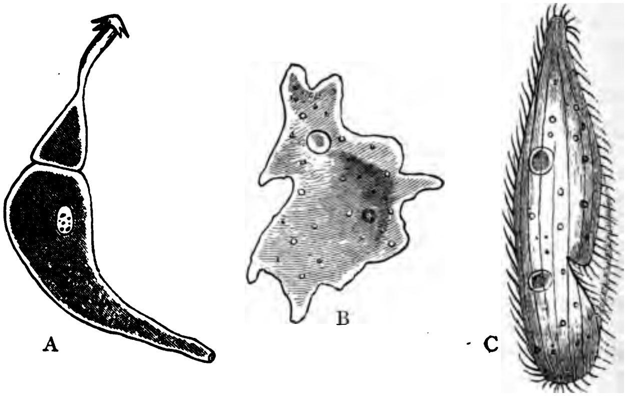

Fig. 3.—Protozoa. A, Gregarine; B, Rhizopod; C, Infusorian.

The sub-kingdom *Protozoa* is usually divided into three great groups or "classes," known by the names of *Gregarinidæ*, *Rhizopoda*, and *Infusoria*, but the first of these needs little more than mention.

CLASS I. GREGARINIDÆ.—The "Gregarines" (Lat. *gregarius*, living in flocks) are remarkable amongst the *Protozoa* in the fact that they do not lead an independent existence, but are *parasitic*, and live in the interior of other animals. They vary in size from less than the head of a small pin up to nearly half an inch, when they look like little worms; and they are found in the intestines of various animals, such as the lobster, cockroach, earthworm, &c. Like other internal parasites, the Gregarines live on the juices of their host, and, apparently as a consequence of not depending on their own exertions for food, possess a very simple, and indeed degraded, organisation. The body (fig. 3, A) is composed of an external membranous envelope, filled with granular protoplasm, and containing in its interior a little oval sac or bladder, which is termed the "nucleus," and is probably connected with reproduction. Sometimes there is a kind of hooked head, but in no case is there any mouth, and the animal lives simply by imbibition through its skin. There are also no distinct organs of locomotion, but the animal moves slowly by a kind of contractile movement of the body.

CLASS II. RHIZOPODA.—This class of the *Protozoa* comprises the most characteristic and typical forms of the whole subkingdom, and derives its name of *Rhizopoda* (Gr. *rhiza*, root; and *pous*, foot), or "root-footed" animalcules, from the fact that they all possess the power of throwing out temporary processes of the body-substance, which they employ in moving about and in obtaining food. These processes can be thrown out from a part or the whole of the surface of the body, and they are termed "pseudopodia," from the Greek words *pseudos*, falsity, and *pous*, a foot. This name is given them because they are not permanent organs like the feet of the higher animals, but can be produced at will, and can be withdrawn again into the substance of the body, into which they melt, without leaving a trace behind.

As types or examples of the *Rhizopoda*, we may briefly consider the *Amœba*, or Proteus-animalcule, the so-called *Foraminifera*, and the Sponges.

The *Amœba* (Gr. *amoibos*, changing) derives both its scientific and its common name from the endless changes of form which it exhibits (fig. 4). It can be obtained for examination either from the waters of stagnant pools, or simply by exposing to light and warmth a little water in which any animal or vegetable substance has been soaked.

The *Amœba* possesses a special interest as exhibiting to us the vital phenomena of a minute free-living mass of protoplasm. Similar masses of protoplasm, even when they form portions of a complex organisation, if similarly free, present similar phenomena. Thus, the little masses of protoplasm which float in the blood of man and the higher animals ("white blood-corpuscles"), as well as other elements of the human body both in health and disease, exhibit actions precisely similar to those of small *Amœbæ*. The *Amœba*, therefore, deserves special study, since we may regard most of its vital phenomena as being simply those inherent in living protoplasm in all its forms.

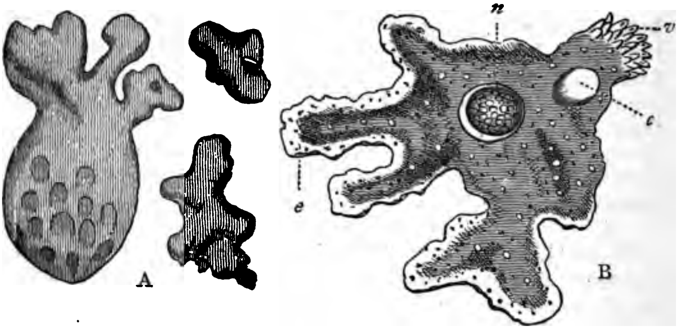

Fig. 4 —A, *Amœbæ* developed in fluids containing organic matter, very greatly magnified (after Beale). B, *Amœba princeps* (after Carter), highly magnified: *c* Rudimentary circulatory organ or heart; *e* Outer, transparent layer of the body.

The *Amœba* is invisible to the naked eye, and can only be studied under the microscope. It has the form of a little mass of jelly-like protoplasm (fig. 4), the outer layer of which is somewhat firmer and more transparent than the rest, whilst the interior contains more or less numerous solid particles or granules, along with larger clear spaces apparently formed by globules of water. Often, also, there are visible minute plants or other microscopic organisms which the *Amœba* has swallowed, but has not digested. In fact we can actually *feed* the *Amœba*, by adding some substance such as indigo to the water, when the particles of the pigment can be seen to be taken into the interior in the manner to be described immediately. As the animal is watched, it will be seen to push out a portion of its substance in the form of a blunt finger-like process or processes in some particular direction. This pushing out of prolongations of sarcode, or pseudopodia, can be effected from almost every part of the body; and the processes themselves assume such diverse shapes that the figure of the animal, when active, is hardly the same for any length of time together. They serve the purpose of feet, and by their means the *Amœba* creeps about with tolerable facility. In fact it might almost be said, without exaggeration, that the animal appears to *flow* in any direction it may wish, much as a drop of any viscous fluid would behave if placed upon a glass slide, the level of which was constantly being altered. When withdrawn, the pseudopodia simply melt into the substance of the body. By means of these extemporised feet the *Amœba* not only changes its place, but also obtains its food. When it comes into contact with any nutritive particle, it wraps a temporary arm round it, and drags it into the interior of the body, to be digested if possible, but if not, to be rejected by a similar but reversed action. There is no permanent mouth therefore; but in this convenient manner almost any part of the surface of the body can be made to do duty as a temporary mouth. There is no digestive cavity or stomach; there are no breathing-organs; there are no organs of the senses; nor is there a nervous system; and there is only a doubtful rudiment of the circulatory system, in the form of a "contractile vesicle." This is a little chamber which expands and contracts at regular intervals, driving the fluid contained in it through the body. The contained fluid is usually said to be derived from the digestion of the food, in which case it would correspond to the blood, and the chamber itself would correspond to the heart, of the higher animals. It is stated, however, that radiating tubes have been seen proceeding from the contractile vesicle, and that these communicate with the exterior. In this case the fluid contained in the vesicle will only be water, and it would correspond with what will afterwards be described as the "water-vascular system." Lastly, the *Amœba* possesses an oval solid body, the "nucleus," which is probably connected with reproduction, but there are no other internal organs of any kind. The *Amœba* appears to reproduce itself chiefly by a process of cleavage, or, as it is technically called, "fission" (Lat. *findo*, I cleave). In this process the body gradually divides or splits into two parts, each of which becomes a separate and independent individual. In other cases a fresh being may be produced simply by the casting off of a single pseudopodium.

More interesting than the *Amœba* from every point of view are the minute shelled animalcules known as *Foraminifera* (fig. 5). The *Foraminifera* are almost all extremely minute, but they are better known than they would otherwise be, in consequence of the fact that they have the power of secreting a hard covering or shell—the "test"—which is composed either of carbonate of lime, or of particles of sand cemented together by some animal cement. For this reason, too, they exhibit a false kind of complexity of structure, for the shells are often very elaborate in their structure, and are usually exquisitely beautiful in their form. At first sight, therefore, we might imagine that the *Foraminifera* were of a very high grade of organisation; and for a long time, indeed, they were actually placed in the same class with the Pearly Nautilus, merely on account of the form of the shell. When we come, however, to examine the soft body contained within the shell, the eye, fortified by the splendid appliances of the modern microscope, can hardly discover anything which could be called *structure* or organisation. The body of any one of the *Foraminifera* consists, in fact, of nothing more than jelly-like structureless sarcode, containing only a few microscopic particles or granules and oil-globules. Even the so-called "nucleus" of the *Amœba* has not been universally recognised in the *Foraminifera*, and no other internal organs are known to exist in the sarcode-body. The *Foraminifera*, however, possess the power of giving out numerous pseudopodia or processes of their body-substance, which agree with those of the *Amœba* in serving for locomotion and for obtaining food. In this case, however, the pseudopodia differ altogether from the blunt and finger-shaped processes of the *Amœba*, since they are very long, attenuated, and thread-like, and interlace with one another towards their extremities (fig. 5, *b*, *c*), so as to form a network like "an animated spider's web" (Carpenter). Under high powers of the microscope, too, the pseudopodia show numerous minute granules or solid particles which are in constant movement and circulation.

As the body of a Foraminifer is enclosed in a hard covering or shell, the pseudopodia can only be emitted wherever the shell is absent; and here we come to an important distinction among the *Foraminifera*. In one group the walls of the shell are not perforated by any holes, and consequently the pseudopodia can only be protruded from the mouth of the shell (fig. 5, *b*). In another group, however, not only are the pseudopodia protruded from the mouth of the shell, but the entire shell is perforated by a number of minute holes, or "foramina," through which the filaments of sarcode are given out (fig. 5, *c*). From this circumstance the name *Foraminifera* has been itself derived (Lat. *foramen*, an aperture; and *fero*, I carry).

The form of the shell in the *Foraminifera* is exceedingly different in different cases. Sometimes it consists of a single chamber of shell including a little mass of protoplasm in its interior, as in the beautiful flask-shaped *Lagena* (fig. 5, *a*). At other times it consists of an assemblage of little chambers, all communicating with one another, and all filled with sarcode. In this latter case, the different chambers are very differently arranged in different kinds, and the resulting form of the shell is very variable, being straight, bow-shaped, spiral, top-shaped, &c.

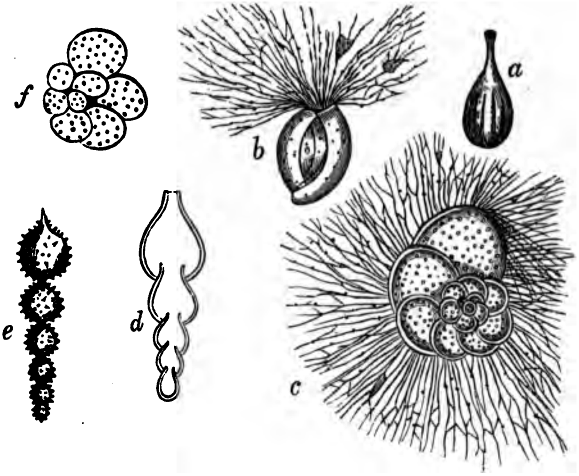

Fig. 5.—Morphology of the Foraminifera. *a Lagena*, having a single-chambered shell; *b Miliola* (after Schultze), showing the thread-like pseudopodia protruded from the mouth of the shell; *c Discorbina* (after Schultze), showing the many-chambered shell, with the pseudopodia protruded from the entire surface of the shell by minute apertures; *d* Section of *Nodosaria* (after Carpenter), showing the chambers; *e Nodosaria hispida*; *f Globigerina bulloides*.

The size of the shell is also very different in different cases. Most of the commoner living forms, though visible to the naked eye, are so small that they cannot be properly made out except by the use of a magnifying-glass or microscope. A few of the fossil *Foraminifera* are quite large and conspicuous objects, sometimes several inches in circumference, but all require the microscope to elucidate their internal structure.

The *Foraminifera* live in the sea, or occasionally in fresh waters. Two or three of the commoner forms may be detected on the fronds of the tangle at low water on our own coasts, but they are much more abundant in warm than in cold seas, and they live mostly in the open ocean, so that they are mainly to be obtained by the use of the dredge or the towing-net. In the tropics and in heated seas, the sand of the sea-shore is often to a great extent composed of the castaway shells of these minute organisms, and the student may readily obtain some of the commoner species for examination by examining the sand which the sponges of commerce contain in their interior before they have been used. One of the most interesting facts as regards the distribution of the *Foraminifera* at the present day, is their great abundance in the various great oceans far from land. Some of them live at the bottom, while others float near the surface, and some, perhaps, enjoy both habits of life. It is established, moreover, that the floor of the deep Atlantic and other great oceans is in many places covered, over large areas, with a peculiar brownish mud or "ooze," which is in many respects exceedingly similar to unconsolidated chalk, and which is almost entirely composed of the minute shells of *Foraminifera* (fig. 6). Foraminiferal mud or "ooze" of this kind has been found in the Atlantic at a depth of nearly 15,000 feet, or not far short of three miles; and we may therefore conclude that extensive deposits of limestone are now in process of being laid down in the deeper parts of the great oceans, and that these limestones are in large part made up of the minute shells of *Foraminifera.*

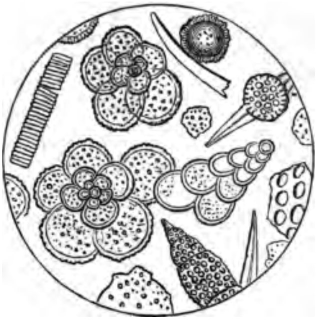

Fig. 6.—Organisms in the Atlantic ooze, chiefly *Foraminifera* (*Globigerina* and *Textularia*), with *Polycystina*, and Sponge-spicules; highly magnified. (Original.)

The *Foraminifera*, also, are of special interest from a geological point of view. The oldest of known fossils—that is to say, the oldest created being that our researches have as yet brought to light—appears to have been a gigantic *Foraminifer;* though there are differences of opinion as to whether it be really a fossil or not. Small as they for the most part are, the shells of the *Foraminifera* are often accumulated in certain localities in such vast numbers that they form rock-masses, which may be hundreds or thousands of feet in thickness, and which may extend over areas of thousands of square miles. The Pyramids of Egypt and the modern city of Paris are built up to large extent out of the skeletons of these minute organisms. In the same way, the great formation of the White Chalk, which stretches from Ireland to the Crimea, and which sometimes attains a thickness of no less than 600 feet, is very largely composed of the microscopic shells of the *Foraminifera.*

Closely allied to the *Foraminifera* is a group of exquisitely beautiful little organisms, which are known as *Polycystina* (fig. 7, *b*). These are all microscopic in size, and they agree with the *Foraminifera* in possessing a structureless sarcode-body, enclosed in a perforated shell, and capable of emitting numerous thread-like interlacing pseudopodia. They differ from the *Foraminifera* in the fact that the shell is always perforated with apertures for the pseudopodia, and that it is composed of flint. The shells are therefore quite transparent and glassy, and they are usually of extreme beauty, being variously sculptured, and often adorned with spines. In other nearly-related forms, such as *Acanthometra* (fig. 7, *a*), the sarcode-body is not enclosed in a distinct shell, but is furnished with long radiating spines of flint. The *Polycystina* live in the sea exclusively, and their shells are commonly found along with those of the *Foraminifera* in the Atlantic "ooze." They are also not uncommonly found aggregated together in such numbers as to form deposits of very considerable extent and thickness. This is the case, for instance, in Barbadoes, where there is a well-known bed, which is called "Barbadoes earth," and is composed almost entirely of the minute flinty shells of the *Polycystina;* and very similar accumulations of the same have been found in the deepest parts of the great oceans.

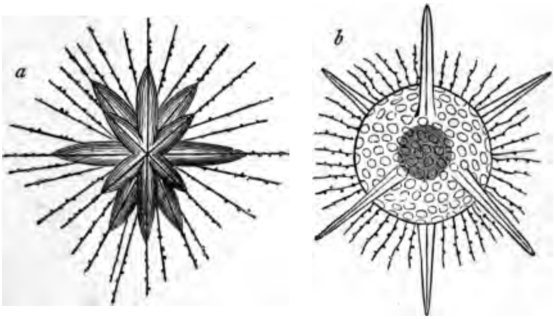

Fig. 7.—*a Acanthometra; b Haliomma*, one of the *Polycystina*, showing the shell and the radiating pseudopodia. (After Müller.)

The last of the *Rhizopoda* which require notice are the Sponges (*Spongida*), forming a singular group of organisms which were long believed to be plants, but are now almost universally regarded as animals. At first sight the Sponges appear to be extremely complicated, but we readily arrive at a conception of their true nature, if we take the view that a Sponge is not a single animal, but is a *colony* or aggregation of partially independent beings. For our present purpose, in fact, we may regard a Sponge as being nothing more than a colony or assemblage of *Amœbæ*, which mostly has the power of secreting for itself a hard framework or skeleton by which the whole structure is supported. If we take one of the common horny sponges of commerce, we find that it is composed of two distinct elements, the "skeleton" and the "sponge-flesh." What we buy as the sponge is not really the animal, but is nothing more than the *skeleton*, from which all the animal matter has been artificially removed. The skeleton of a horny Sponge (fig. 8, A) is composed of innumerable horny fibres, all inextricably interwoven and interlaced, so as to form a species of framework, which is perforated by numerous apertures and canals of different sizes. The skeleton is in some instances further strengthened by numerous needle-like bodies of various forms, which are termed "spicula," and which consist of flint. In certain other Sponges the skeleton is entirely composed of spicules, which are composed of flint in the so-called "siliceous" sponges, and of lime in the "calcareous" sponges.

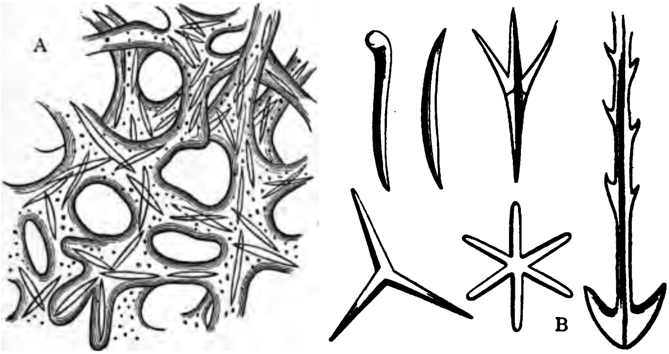

Fig. 8.—A, Fragment of the skeleton of a horny sponge (after Bowerbank), showing interlacing horny fibres with spicula. B, Different forms of the spicules of sponges, much magnified.

In any case, when the sponge is alive, the skeleton is entirely covered by the "sponge-flesh," which forms a gelatinous covering, resembling white-of-egg in texture, for every portion of the entire framework, both within and without. This "flesh" is truly the animal element of the sponge, and it is, of course, removed in the sponges which we employ. If, however, a portion of this slimy sponge-flesh be taken and placed under the microscope, it is found to be composed of a great number of minute masses of sarcode (fig. 9, A), all more or less completely independent of one another, and each very closely resembling the animalcule which has been already described as the *Amœba.* Each of these separate "sponge-particles," as they are called, can thrust out little processes of sarcode, in the form of pseudopodia, and in some cases each is furnished with a vibrating filament or "cilium" (fig. 9, B and C). The sponge-particles obtain food by means of these processes of sarcode, just as we saw in the *Amœba.* The *Amœba,* however, is free, and can go in search of its food. The sponge-particles, on the other hand, are members of a community or colony, which they cannot leave; and for this reason some arrangement is necessary by which food may be brought to them without their going to look for it. This is effected in a very interesting manner by what is called the "aquiferous" or water-carrying system of the sponge. If a common sponge be examined, it will be at once seen that the surface exhibits two distinct sets of holes. The apertures of the one set are extremely minute and very numerous, and they are called the "inhalant apertures" or

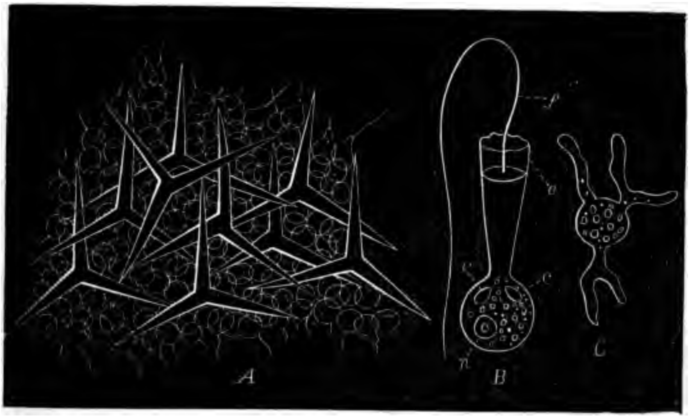

Fig. 9.—A, Part of a Sponge (*Grantia*), greatly magnified, showing the three-rayed needles or "spicula" which form the skeleton, and the minute sponge-particles in which these are embedded. B, A single sponge-particle, much magnified, with a vibrating filament or "flagellum" (*f*), surrounded by a membranous collar (*a*). C, A single sponge-particle, much magnified, throwing out processes of sarcode or "pseudopodia."

"pores." The other apertures are very much fewer in number and much larger in size, and they are called the "exhalant apertures" or "oscula." The large apertures or oscula are permanent, but they can be opened or closed at will; whilst the smaller apertures or pores appear to be formed afresh wherever they are required. If a sponge be examined in a living state, it is found that these apertures, and the canals which connect them, serve to maintain a constant and singular circulation of water through every portion of the sponge. The water is admitted by the smaller apertures or pores (fig. 10, *b b*), circulates through the entire organism, and is expelled again in steady currents from the larger apertures or oscula. In this way particles of food are incessantly brought within the reach of every individual sponge-particle, and the outgoing currents carry off with them all the useless matters which might otherwise accumulate injuriously within the organism. A sponge, in fact, may be compared to "a kind of subaqueous city, where the people are arranged about the streets and roads in such a manner that each can easily appropriate his food from the water as it passes along" (Huxley). The mechanism by which this circulation of water is maintained is found in certain chambers (fig. 10, *c c*) in the interior of the sponge, which are lined with sponge-particles, each of which carries a single vibrating filament or "cilium." By the lashing movement of these the water is driven into the deeper parts of the sponge.

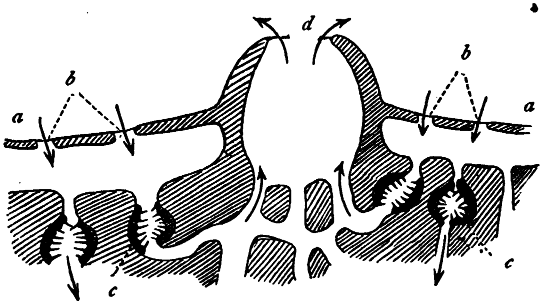

Fig. 10.—Diagrammatic section of *Spongilla* (after Huxley). *a a* Outer layer of the sponge; *b b* Inhalant apertures or "pores;" *c c* Ciliated chambers; *d* An exhalant aperture or "osculum."

It follows from the above that one of the most striking external features in any ordinary sponge, is the existence at the surface of two sets of apertures, by which the water passes in and out of the organism. In the simplest form of sponge (fig. 11, B) the body is perforated with a vast number of minute apertures ("pores") for the entrance of the water, and there is one large aperture ("osculum") by which the water is again expelled. In this case, the body may be regarded as a simple cylindrical tube, fastened by its base, with a central cavity which communicates with the external world by a large terminal aperture, and numerous small lateral perforations. More commonly, however, a sponge consists of a common mass, perforated not only by innumerable minute pores, but also by many large openings for the expulsion of the water which has circulated through the body.

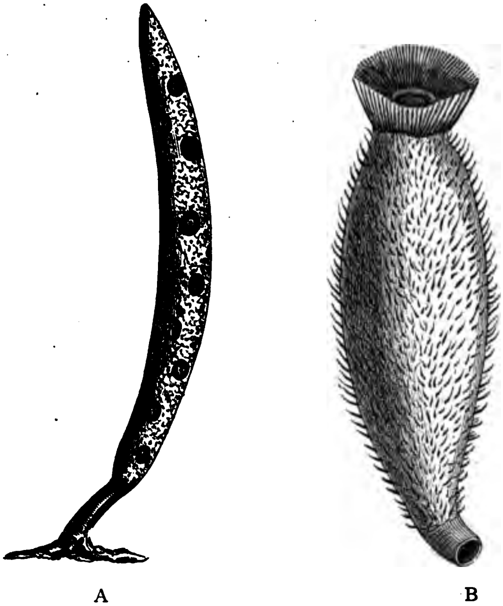

Fig. 11.—A, *Axinella polypoides*, a fibrous sponge showing oscula and pores. B, *Sycandra ciliata*, a calcareous sponge, enlarged, showing the single terminal osculum. (After Schmidt.)

Sponges, when full-grown, are almost always fixed to some foreign object. Usually they are rooted firmly to rocks; but they may simply live half buried in the sand, or they may be attached to the shells of crabs or other marine animals. Some of them bore singular winding holes and tunnels in the shells of oysters and other shell-fish. The young sponges have little hair-like processes ("cilia"), by the vibration of which they swim about actively, and they thus have the power of spreading from place to place. When the young sponge, however, finds a suitable locality, it fixes itself, and becomes deprived of the power of locomotion.

Most of the sponges are not particularly attractive in their external appearance, except to naturalists; but some of the flinty sponges, such as the Venus's Flower-basket, are amongst the most beautiful of natural objects, owing to the exquisite pattern of the skeleton and its glassy texture. With the exception of the single genus *Spongilla*, which is found in lakes and rivers, all living sponges inhabit the sea. Many of the commoner forms may be found on our own coasts at low water; but others live in almost the deepest recesses of the ocean that have as yet been explored by the dredge. The sponges of commerce owe their value to the possession of a horny fibrous skeleton without spicules. The best of them are obtained in the Mediterranean, but inferior kinds are imported from the West Indies. They grow firmly attached to rocks below the sea, and are obtained either by dredging or diving.

CLASS III. INFUSORIA.—The last class of the *Protozoa* is that of the *Infusoria*, or so-called "Infusorian Animalcules." The animals included under this head are, without exception, microscopic in size, and they are found in countless numbers in most collections of stagnant water, and in the sea. They acquire their name of *Infusoria*, however, from their occurrence in another locality under the following singular circumstances: If, namely, a little water be taken in which any animal or vegetable substance has been soaked, we obtain what is called an "organic infusion"—namely, a fluid containing organic matter in solution. If this fluid be boiled, so as to kill all living beings which may be contained in it, and be then allowed to stand for a few days in a warm place exposed to light, a great number of living organisms may be detected in it by means of the microscope. Amongst these will generally be found some of the members of the present class, and hence the name applied to them.

Most of the *Infusoria* are free-swimming independent animals, but some of them form colonies by budding, and these present a striking resemblance to miniature plants. As a type of the former group may be taken *Paramœcium*, or the "Slipper-animalcule," as we may call it; and of the latter, the pretty little Bell-animalcule or *Vorticella*. The two most important characters by which the *Infusoria* are distinguished as a whole from the other groups of the *Protozoa*, are the possession of a mouth and short gullet, and the inability to thrust out those temporary processes of sarcode which have been described under the name of pseudopodia, and which are so characteristic of the *Rhizopoda*.

Paramœcium (fig. 12) presents itself in the form of a little melon- or slipper-shaped creature, almost perfectly transparent, and showing only a few dark granules and circular spaces. This is all that a first glance would reveal, but the observer would be immediately struck with its great activity in the absence of any conspicuous organs of locomotion. Careful observation, however, soon shows that *Paramœcium* owes its power of changing its place to innumerable little microscopical filaments or hairs which are called "cilia" (Lat. *cilium*, an eyelash). These cilia cover the entire surface of the body, and are in almost constant vibration, lashing to and fro with a speed too great to be followed by the eye, but being at the same time under the control of the animal. Not only does the animal move by means of the combined efforts of the innumerable cilia, but it likewise obtains food by the same agency. The cilia, namely, set up currents in the surrounding water, so that each *Paramœcium* forms the centre, as it were, of a little whirl-

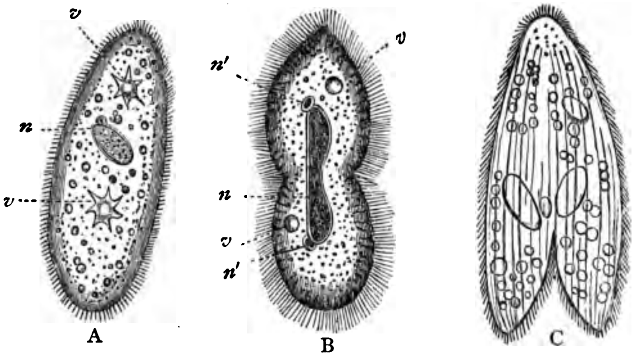

Fig. 12.—A, *Paramœcium*, showing the nucleus (*n*) and two contractile vesicles (*v*). B, *Paramœcium bursaria* (after Stein), dividing transversely. C, *Paramœcium aurelia* (after Ehrenberg), dividing longitudinally.

pool, and it is by means of these currents that particles of food are brought within the reach of the mouth.

Unlike the *Amœba*, the animal possesses a distinct mouth and short gullet, but it has no definite stomach. The particles of food pass into the soft semi-fluid protoplasm which constitutes the central portion of the body, and there they undergo a kind of circulation or rotation. Often each of the engulfed particles is surrounded by a little drop of water, forming a clear circular space; and the appearance thus produced gave rise formerly to the belief that each of these animalcules possessed many stomachs. Undigested particles of food are rejected by a minute vent situated near the mouth.

The only internal organs possessed by *Paramœcium* are one or more "contractile vesicles," and the structures which are termed the "nucleus" and "nucleolus." The latter are organs connected with reproduction; and the contractile vesicles are like those previously described in the *Amœba*, being contractile chambers filled with a colourless fluid, and apparently discharging the functions of a heart.

The Slipper-animalcules not only produce eggs, but have the power of reproducing themselves by cleavage or division of their own bodies into two parts, each of which becomes an independent being. The division may be longways or across

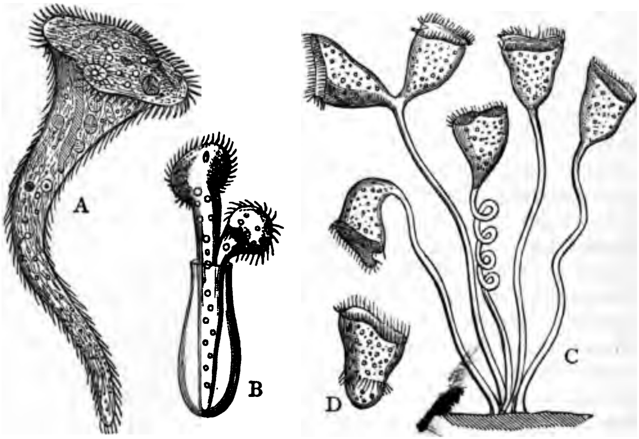

Fig. 13.—A, *Stentor Mülleri*. B, *Vaginicola crystallina*. C, Group of *Vorticellæ* D, Detached bud of *Vorticella*, showing the posterior circlet of cilia.

(fig. 12, B and C), and multiplication can by this method be very rapidly carried on.

The Bell-animalcules or *Vorticellæ* (fig. 13, C) may be found in any stagnant pool, attached to the stems of aquatic plants, and they form an excellent example of those *Infusoria* which are permanently rooted and fixed to one spot in their adult condition. The body of each is essentially like that of *Paramœcium* in structure, but is cup-shaped, and has the cilia collected into a kind of fringe round the upper margin; whilst the base is attached to the object on which the colony grows, by means of a flexible contractile filament or stalk. A kind of transition between *Vorticella* and *Paramœcium* is afforded by the so-called Trumpet-animalcule or *Stentor* (fig. 13, A), which can detach itself and swim about at will, at the same time that it is ordinarily fixed by its thinner extremity to some solid object.

The forms we have just been speaking of move about, or obtain their food, by the vibration of minute hair-like processes or cilia,—hence the name of "Ciliated Infusoria" applied to them. Others, however, have locomotive organs in the form of long whip-like filaments, and others have little radiating processes furnished with sucking-discs at their ends.

SUB-KINGDOM II.—CŒLENTERATA.

CHAPTER II.

CHARACTERS OF THE SUB-KINGDOM.

THE second great primary division or sub-kingdom of animals is that of the *Cœlenterata* or "hollow-entrailed" animals (Gr. *koilos*, hollow; *enteron*, intestine). This sub-kingdom embraces the Sea-anemones, Corals, Sea-jellies, Sea-firs, Sea-pens, and other allied animals, all of which are characterised, amongst other things, by having their bodies built up of parts, which are arranged in a more or less star-like or "*radiate*" manner. Hence these creatures were long known as "Radiate Animals." So many other animals of different kinds were, however, included in the old sub-kingdom *Radiata*, that naturalists have generally abandoned this term. Most of the Cœlenterate animals would come under the popular term of "Zoophytes" or plant-animals (Gr. *zoön*, animal; *phuton*, plant), from the external resemblance which many of them bear to plants.

The distinguishing feature of the *Cœlenterata*, from which the sub-kingdom takes its name, is that the "body-cavity," or the general space included within the walls of the body, is in direct communication with the outer world through the mouth. Sometimes, as in the Hydra (fig. 14, B), the body is a simple, double-walled sac, into one end of which the mouth opens directly; sometimes, again, the structure of the body is not quite so simple, and the mouth opens into a short stomach, which in turn opens into the body-cavity, as in the Sea-anemones. It follows from the above, that the food in the Cœlenterate animals passes directly into the general cavity of the body; and the process of *digestion* is therefore carried on, in whole or in part, *in the body-cavity*. This is a very different state of things from what exists in the higher animals, where the digestive cavity never opens into the body-cavity, and the body-cavity, therefore, never communicates with the external world through the mouth.

In addition to the above-mentioned peculiarity, all the Cœlenterate animals possess bodies which are essentially composed of two distinct layers—an outer layer, which forms the skin; and an inner layer, which lines the body-cavity and interior of the animal. (These layers are diagrammatically represented by the dark and light lines in fig. 14, B). The outer layer of the body is also furnished with numerous little organs of offence and defence, which are termed "thread-cells" or "nettle-cells," and which give the animal the power of stinging to a greater or less degree. Each thread-cell (fig. 15) is a little microscopic sac or bladder, filled with fluid, and carrying at one end a long filament or thread, the structure of which is often very complicated. The thread can be darted out with great rapidity and force, and it is used by the animal in capturing its prey, apparently producing some poisonous or benumbing effect. In most Cœlenterates, the thread-cells are

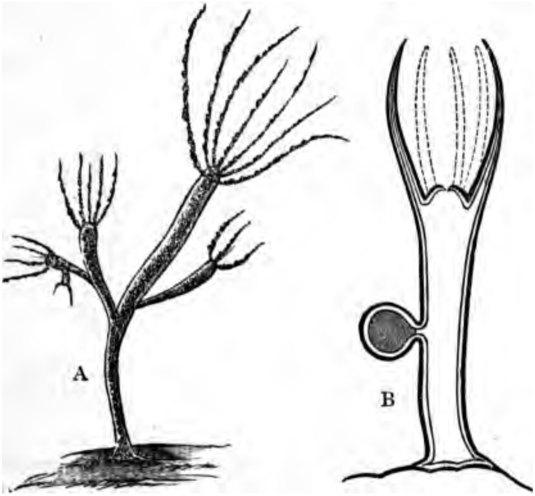

Fig. 14.—A, The Common Hydra (*Hydra vulgaris*), carrying young *Hydræ* which it has produced by budding, considerably magnified (after Hincks). B, Diagrammatic section of the *Hydra*, showing the mouth surrounded by the tentacles, and the disc of attachment; the dark and light lines indicate the two layers of the integument, and on one side of the body is shown a single large egg. The mouth opens directly into the general cavity of the body.

too weak to pierce the human skin, and consequently most of these animals may be handled by man without injury. Some of the Sea-anemones, however, and more especially the great Sea-blubbers, sting more or less severely, giving rise in thin-skinned people to a good deal of irritation, and sometimes even producing dangerous symptoms. Finally, a general character of the *Cœlenterata* is found in the fact that the organs round the mouth are arranged in a star-like or *radiate* manner, and this arrangement often extends to the internal organs as well.

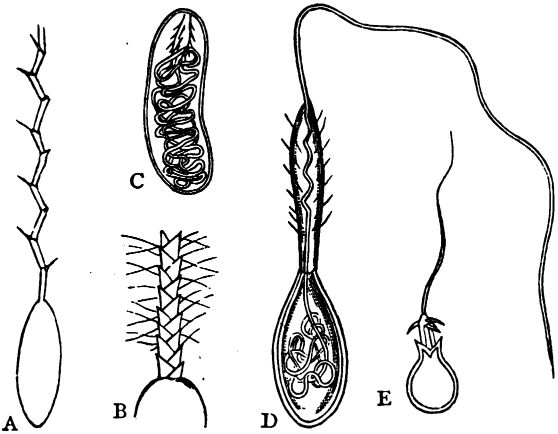

Fig. 15.—Thread-cells of Cœlenterate animals, greatly magnified. A and B, Thread-cell of a coral (*Caryophyllia*), with the thread everted. C and D, Thread-cell of a Sea-anemone (*Corallimorphus*), in its quiescent and active condition. E, Thread-cell of *Hydra*, with the thread everted.

The sub-kingdom *Cœlenterata* is divided into two great divisions or classes, termed respectively the *Hydrozoa* and the *Actinozoa*. In the *Hydrozoa* there is no digestive cavity distinct from the general body-cavity, the mouth opening directly into the cavity of the body. In the *Actinozoa*, on the other hand, there is a distinct digestive sac or stomach; but this opens below directly into the body-cavity, so that the two freely communicate with one another. The former division includes the Sea-jellies, Sea-firs, and their allies; the latter comprises the Corals, Sea-anemones, &c.

HYDROZOA.

CHAPTER III.

HYDROID ZOOPHYTES.

IN all the HYDROZOA, as just mentioned, there is *no distinct stomach, but the mouth opens into the body-cavity directly, so that the body-cavity actually becomes the sole digestive cavity.* An additional character of the class is that *the reproductive organs are in the form of external processes of the body.* (See fig. 14, B.)

The *Hydrozoa* are all aquatic in their habits, and with the exception of two genera, they are all inhabitants of the sea. The class includes a vast number of animals which need not be discussed here, but we may briefly consider the general characters of the four most important sub-classes into which the *Hydrozoa* are divided—namely, the Hydroid Zoophytes (*Hydroida*), the Oceanic Hydrozoa (*Siphonophora*), the Sea-blubbers and their allies (*Lucernarida*), and the Millepores and their allies (*Hydrocorallinæ*),—illustrating these by typical examples.

SUB-CLASS I. HYDROIDA.—The members of this class are usually spoken of as "Hydroid Zoophytes," from their resemblance to the Fresh-water Polype (*Hydra*), which belongs to this division, and may be considered as its type.

The common *Hydræ* or Fresh-water Polypes may be found in tolerable plenty in most of our ponds, and are quite visible to the unassisted eye. The body of the *Hydra* (fig. 16) is in the form of a cylindrical tube, composed of the two fundamental membranes, an outer and an inner, of which the former contains numerous thread-cells. At the base of the cylindrical body is a kind of sucker, by which the animal can attach itself to some foreign object, such as a piece of water-weed. It is not, however, permanently fixed, but can detach itself and change its place at will. At the opposite end of the body is placed the mouth, surrounded by from five to fifteen small filaments, which are arranged in a circle, and are known as the "tentacles." The tentacles consist of tubular prolongations of both the outer and inner layers of the body, and they are richly furnished with thread-cells. In some species they are longer than in others, but all possess the power of drawing the tentacles in at pleasure, and again pushing them out, to a length which sometimes many times exceeds the entire length of the body. The tentacles are the organs by which the *Hydra* catches its food, in which operation they not only act mechanically, seizing the prey and conducting it to the mouth, but they appear also to exercise a benumbing influence upon the animals grasped by them. The mouth opens directly into a long cylindrical cavity, which is excavated along the whole length of the body, and which is truly the body-cavity. It is here, however, that the digestion of the food is carried on, and it is therefore to be regarded as being at the same time the stomach. As before said, the outer layer, both of the body and tentacles, is richly furnished with minute offensive weapons known as "thread-cells," or "nettle-cells." Each of these (fig. 15, E) con-

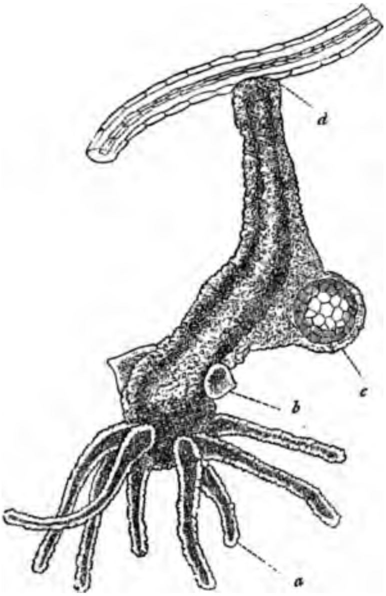

Fig. 16.--The Green Fresh-water Polype (*Hydra viridis*), suspended head downwards from the stem of an aquatic plant. *a* One of the tentacles; *b* One of the externally-placed male reproductive organs; *c* Egg, also placed externally; *d* Disc of attachment.

sists of a little bladder, in the interior of which is coiled up a long filament or thread. When the sac is touched, the thread-like dart within it is thrust out with the rapidity of lightning, its length often exceeding that of the cell many times.

The *Hydra* can be readily kept in confinement, and exhibits many phenomena of great interest. It is a voracious little animal, and feeds upon small crustaceans, worms, the aquatic young of insects, and the like, which it grasps with its outstretched tentacles, and apparently paralyses by means of its thread-cells. During the summer time, when food is plentiful and the animal is vigorous, the *Hydra* produces young ones by a process of budding. From some part of its surface it throws out a little knob or bud, which is composed of the two layers which wall in the body-cavity of the parent, and itself includes a central space. A mouth and tentacles are developed at the free end of the bud, and thus a perfect young *Hydra* is produced. Often we may meet with an old *Hydra* carrying several young ones which have been formed in this way out of buds (fig. 14, A); but in an ordinary way, the young are cast off to lead an independent existence so soon as they are matured. In the autumn, again, when the temperature is low and food scarce, the *Hydra* ceases to bud, and produces true eggs in the form of one or more large rounded protuberances of the body-wall (fig. 14, B; and fig. 16). These eggs are fertilised, and are ultimately developed into fresh individuals.

The *Hydra* is further noticeable for its extraordinary power of resisting mutilation and mechanical injury, as first pointed out by the Abbé Trembley of Geneva. Thus, the body of the *Hydra* may be divided into as many portions as we please with a knife, and the result is that, instead of the animal being killed, all of the fragments become developed into perfect Polypes. Mechanical injury thus serves simply as a method of multiplication, and nothing short of absolute annihilation seems to produce its actual death.

The *Hydra* is a "simple" animal, but the remaining members of the Hydroid Zoophytes are mostly what are called "compound" animals, and before considering these it is necessary to understand the meaning of these terms. There is no difficulty in understanding what is meant by a *simple* animal, for it is simply what, in ordinary language, we call an "individual." A dog, a fowl, or an oyster, is a "simple" animal, and we have no difficulty in appreciating the *individuality* of each of these. If we analyse this individuality, however, we find it to arise from the fact that each of these animals is the result of the development of one egg, and that no similar animal can be produced again, except by the production of another similar egg. This is the case with all the Vertebrate Animals, and with most of the higher Invertebrates; but a very different and much more complicated state of things exists in many of the lower Invertebrates. In many of these latter, the egg gives rise, not to one single animal, but to a kind of *colony* or *society*, formed of several, sometimes of thousands, of semi-independent beings, more or less closely united with one another.

The method in which these "*compound*" animals or colonies are produced is not difficult to understand. They are not formed directly out of the egg, but are the result of a gradual growth. The egg gives rise in the first instance to a simple organism, and this in turn *repeats itself*, either by throwing out *buds* or by *cleaving* itself into distinct portions, each of which becomes developed into a new being similar to that producing it. In fact, it is like the growth of a tree—which, truly, is a compound organism. The seed of a tree produces a young plant which has at first only one or two leaves; but the young plant has the power of throwing out buds, till ultimately it may possess many thousands of leaves, all produced by budding from the original seedling, and all united into one whole. And the leaves of a tree may to a certain extent be considered as semi-independent beings. Each has the power of absorbing and digesting nutritive material; the life of the whole tree is independent of the life of each individual leaf. The tree is kept alive and is enabled to grow by the combined exertions of all the leaves, but it can lose many of them, or all of them for a time, without itself being killed.

We may therefore fairly compare a compound animal to a tree with its leaves; but some striking peculiarities present themselves in the case of compound animals. In a tree we have a colony composed partly of leaves and partly of flowers, united by the branches and trunk, and remaining connected together so long as they are actively alive. We have further to notice that the leaves and flowers have different functions, the leaves serving to *nourish* the tree, whilst the flowers are concerned with the production of *seeds*, and therefore with *reproduction*. In the case of compound animals, the state of things differs in different cases, the following being some of the chief variations observed:—

Firstly, the colony may consist of a number of semi-independent beings, all united, as it were, by their integument or skin, and each perfect in itself. In such a case each member of the colony is able both to nourish itself and to produce eggs, and the colony resembles a tree chiefly in the fact that it is produced by budding from one original egg. As an example of this we may take the animals which will subsequently be spoken of as Sea-mats (Polyzoa). In these (fig. 17) we are presented with plant-like colonies, composed of numerous similar and half-independent beings, each of which has the power of growing and feeding itself, and of producing eggs.

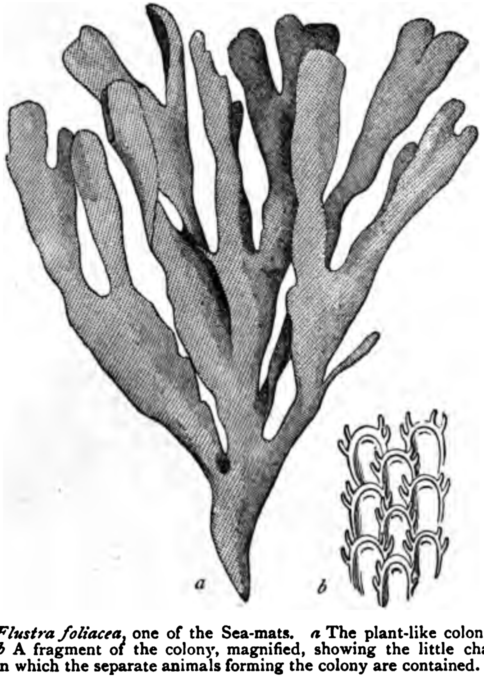

Fig. 17.—*Flustra foliacea*, one of the Sea-mats. *a* The plant-like colony, natural size; *b* A fragment of the colony, magnified, showing the little chambers or cells, in which the separate animals forming the colony are contained.

Each egg produces a colony of this kind, the original being which springs from the egg having the power of repeating itself by budding.

Secondly, the colony or compound organism may consist of *two sets of semi-independent beings*, all united together, but discharging different functions, the one set being concerned with the nutrition of the colony, whilst the other set is concerned with laying eggs, and therefore with reproduction. This is the case with many of the Hydroid Zoophytes (fig. 18), and here the parallelism with a tree is complete. The tree has leaves and flowers, all forming parts of one whole, but discharging different functions, and differing considerably in appearance and form; and precisely the same is the case with the Zoophyte.

Thirdly, we have a group of cases in which the colony consists, as in the preceding, of two sets of members, one of which

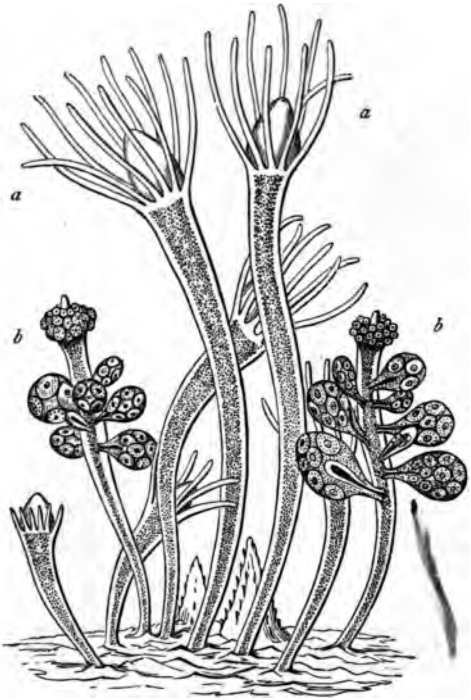

Fig. 18.—A portion of the colony of a Hydroid Zoophyte (*Hydractinia echinata*) enlarged. *a a* Nutritive members of the colony; *b b* Generative or egg-producing members of the colony. (After Hincks.)

is devoted to nutrition and the other to reproduction; but there is the remarkable new feature that *the reproductive buds do not remain permanently connected with the parent colony. The nutritive* members of the colony remain permanently attached to one another, but the reproductive members are early detached from the colony to lead an entirely independent existence, and they may increase in size after detachment till they exceed many hundred times the dimensions of the original growth which produced them. It is as if a tree could throw off its flowers to lead an independent life, and that these flowers should have the power of growth and nutrition, so that they might ultimately much exceed the whole tree in bulk. These detached reproductive buds differ greatly from the original colony in form and appearance—so much so that they were long supposed to be distinct animals—but they only live till they are able to produce eggs, and their eggs give rise, not to beings like themselves, but to plant-like colonies similar to those by which these strange locomotive buds were in the first instance produced. This peculiar "alternation of generations," as it has been termed, occurs, as we shall immediately see, in many of the Hydroid Zoophytes.

The names used to express the different parts of a compound Hydroid Zoophyte are numerous; but it is not essential to know more than the following. The semi-independent members of the colony, which are concerned with its growth and nutrition, are called the "*polypites*;" the common fleshy stem or trunk which carries the polypites is called the "*cœnosarc*" (Gr. *koinos*, common; *sarx*, flesh); the horny case or sheath with which the colony is invested is called the "*polypary*;" and the reproductive members of the colony, whether free or attached, are known by the general name of "gonophores" (Gr. *gonos*, offspring; and *phero*, I carry).

Having premised so much, we may now briefly consider the characters and life-history of some of the commoner compound Hydroid Zoophytes. The colonies formed by these singular animals are very common on most coasts, and are easily recognised by their plant-like form, and by the brown horny integument or skeleton with which the outer surface of the colony is protected. They are rooted to some foreign object, and are usually regarded as being sea-weeds; but they are truly animals, and are generally known by the popular names of "Corallines," "Sea-firs," and "Sea-wreaths."

As a good and far from uncommon example of a well-marked group of the compound Hydroid Zoophytes, we may take the so-called "Pipe-coralline" (*Tubularia*). This beautiful zoophyte (fig. 19) inhabits the sea, and is gregarious in its habits, consisting of numerous clustered horny tubes, which resemble straws in appearance, and are fixed by their bases to some solid object, such as a shell or stone. Each tube is filled with a soft semi-fluid reddish substance, and from its open extremity can be protruded a single polypite. The polypites are bright red in colour, and cannot fully be withdrawn within their tubes. The mouth is placed at the free end of the polypite, and is surrounded by two rows of tentacles, one consisting of numerous short tentacles, placed directly round the mouth, whilst the other is composed of from thirty to forty filaments of much greater length, arising from the polypite about its middle or near the base. Near the insertion of these long tentacles, at proper seasons, are produced buds, in which the elements of reproduction (the ova and sperm-cells) are produced; but the buds themselves are not detached from the polypite. These "generative buds," as just said, in *Tubularia*, and in all the other *Hydrozoa* in which they occur, are technically called "gonophores."

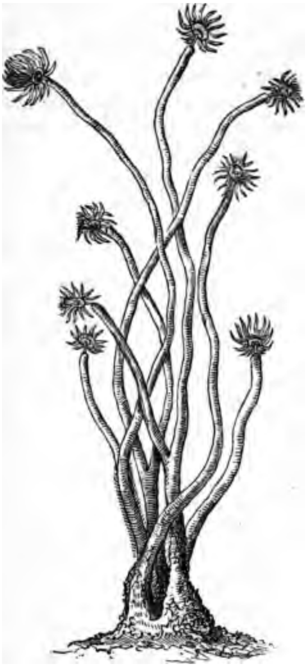

Fig. 19.—Fragment of *Tubularia indivisa*, natural size.

As another example of the Hydroid Zoophytes, we may take the Sea-firs, technically called *Sertularians* (fig. 20). Every visitor at the seaside is acquainted with the Sea-firs and their allies; but they are usually, in fact almost invariably, set down as sea-weeds. What we pick up, however, on the shore, is not the true animal, but is simply its outer covering or skeleton, which is composed of a brown horny substance. To form an accurate idea of a Sea-fir or Sertularian, we have two things to place before our imagination. We must, firstly, imagine that we have a number of little animals (fig. 20, *b*), in all essential points of their structure exactly similar to the *Hydra*, but all permanently united to one another by a common branched stem or trunk (the "cœnosarc"). This assemblage of little Hydra-like beings—polypites—forms a permanent colony, all the members of which are attached for life to one another. The entire colony is produced by budding from a single primitive polypite, and each polypite is exactly like the *Hydra* in essential structure. Each, namely, consists of a little cup-shaped or cylindrical body, enclosing a single chamber, which is both body-cavity and stomach, and having at one end a mouth surrounded by a circlet of tentacles (fig. 20, *b*). At its lower end the body-cavity opens into a tubular cavity, which is everywhere excavated in the substance of the common connecting trunk or "cœnosarc," and which is filled with a nutritive fluid, by means of which the vitality of the whole colony is maintained. The *animal*, then, of a Sertularian, is composed of this colony of hydra-like polypites, united by a branched trunk. To complete, however, our conception of a Sertularian, we have, secondly, to imagine that the entire colony is invested by a strong brown horny case or sheath. This structure—the so-called "polypary"—forms a closely adherent sheath or covering for the whole "cœnosarc" or common trunk, as it does in *Tubularia*; but it differs from the latter in also expanding to form little cups for each separate polypite (fig. 20, *a′*). These little cups are open at one end, and each polypite has the power of putting out its head from the open aperture of its little

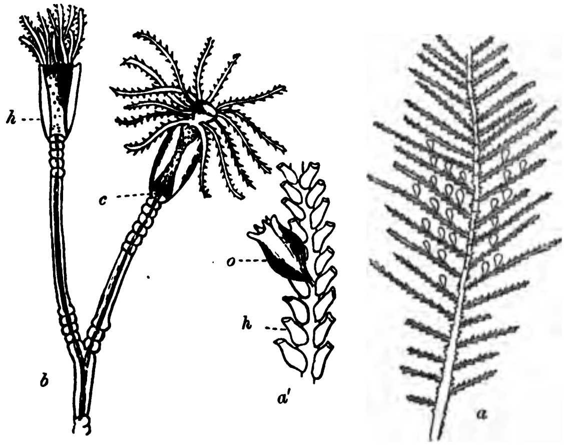

Fig. 20.—*a* Fragment of *Sertularia pinnata*, natural size; *a′* Branch of the same magnified, showing the little cells ("hydrothecæ") in which the polypites are contained, and also a reproductive capsule; *b* Fragment of *Campanularia neglecta* (after Hincks), showing the polypites in their cups. Magnified.

cup-shaped case, or again of retiring entirely within it for protection. They are technically known as "hydrothecæ" (Gr. *hydra;* and *theke*, a case).

These two conceptions give us accurately the structure of any common *Sertularian;* but we now know that this is only half their history, and we have next very briefly to consider some very remarkable facts concerning the mode in which these plant-like colonies are reproduced. The entire colony of a *Sertularian*, such as has been described, is produced by budding from a single primitive polypite, and is permanently fixed and rooted. None of the ordinary polypites have any power of producing eggs, and it is quite obvious that the species could never spread from one place to another, and so maintain its existence, unless there were some special means provided to insure this. At certain times of the year, however, we find, if we examine any common Sertularian, that, besides the ordinary polypites or nutritive members of the colony, there are larger and differently-shaped structures, usually enclosed in urn-shaped receptacles, attached to the branches (fig. 20, *a*). These are receptacles in which are peculiarly-modified polypites, the function of which is to produce the eggs which the ordinary polypites are unable to develop. When the eggs are ripe, the receptacles, or "ovarian capsules" as they are often called, rupture, and set the embryos free into the surrounding water. The embryo Sertularian is a little oval body, which is covered with vibrating cilia, by means of which it swims about actively. After a time the active embryo fixes upon some suitable locality, attaches itself by one extremity to some solid object, develops a mouth and tentacles at the opposite end, and becomes in every respect an animal like the common *Hydra.* It now begins, however, to throw out buds, and it encases itself in a horny sheath, till ultimately there is produced another plant-like colony, just like the one on which the ovarian vesicles were produced.

Still more extraordinary facts are observed in the common Bell-Zoophytes (*Campanularians*). These beautiful organisms (fig. 20, *b*; and fig. 21) form plant-like colonies, quite resembling those of the *Sertularians* except in the fact that the polypites are supported on little stalks, instead of being attached directly to the sides of the branches. In the Sertularians, as we have just seen, the reproductive buds are not detached from the parent colony, but simply discharge a number of ciliated embryos, which swim about till they find a suitable resting-place. In the Campanularians, on the other hand, the reproductive or egg-producing polypites ("gonophores") are bodily detached from the parent colony. The liberated polypite drops off from the colony, like a flower from its stalk, but instead of dying, it continues to live and grow, sometimes attaining very considerable dimensions; and it leads a completely independent existence for a longer or shorter period. It now constitutes one of the creatures which are popularly known as "Jelly-fishes," and are technically called "Medusoids." In fig. 22 is represented the Jelly-fish or free-swimming

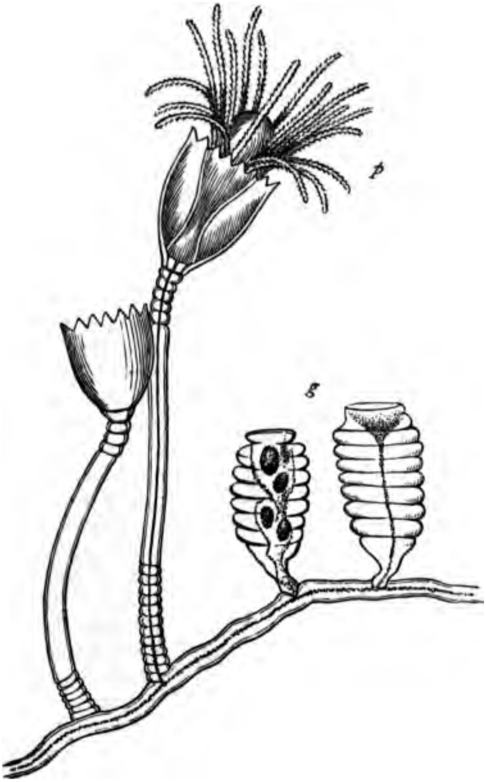

Fig. 21.—Portion of the colony of *Clytia Johnstoni*, one of the *Campanularians*, magnified. *p* Nutritive polypite; *g* Capsules in which the reproductive polypites are produced.

reproductive bud which is thrown off by *Clytia Johnstoni*, part of the fixed colony of which is represented in fig. 21. A reference to these two figures will at once show how unlike these two organisms are, and will prevent us from feeling any wonder that beings so different in form and in habit of life should have been long regarded as entirely distinct from one another.

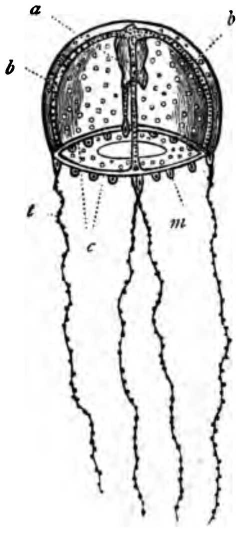

Fig. 22.—Free Medusoid of *Clytia Johnstoni* (after Hincks). *a* Central polypite; *b* Radiating canals of the disc; *c* Circular canal; *m* Marginal bodies or eye-specks; *t* Tentacles.

In structure, the Jelly-fishes or Medusoids consist each of a delicate, transparent, glassy bell or disc, from the under surface of which, like the clapper of a bell, is suspended a single polypite. The whole organism swims gaily through the water, propelled by the contractions of the bell or disc; and no one would suspect that it had any relationship to the rooted and plant-like Zoophyte from which it was originally budded off. The central polypite is furnished with a mouth, which opens into a digestive cavity or stomach. From the stomach arise four radiating canals (*b b*), which proceed to the margin of the bell, where they are united by a circular vessel (*c*) which runs round the mouth of the bell. From the circumference of the bell hang also a number of delicate filaments or tentacles (*t*), and the margin is adorned with a number of brightly-coloured spots (*m*), which are probably rudimentary organs of vision and hearing. Lastly, the mouth of the bell is partially closed by a delicate transparent membrane, the so-called "veil." Thus constituted, these beautiful little beings lead an independent and locomotive existence for a longer or shorter period. Ultimately ova and sperm-cells are produced in special organs, which are developed in the course of the radiating canals of the disc, or in the walls of the polypite. The eggs give rise to ciliated embryos, which, according to all our ordinary notions, ought to become Jelly-fish; the young in ordinary cases developing itself into the organism by which the egg was produced.

This is not the case here, however, but the embryos fix themselves, and become developed by budding into the fixed plant-like colony, from which the Medusoids were originally derived.

The plant-like colonies of the Hydroid Zoophytes are found both between tide-marks and in all the shallower seas. They are rooted to stones, the fronds of sea-weeds, the shells of molluscs and crabs, or other submarine objects, and a great many different kinds are now known. The Jelly-fishes or "Medusoids"[1] swarm in the open sea in the warmer months of the year. They are active and voracious little creatures, and are rendered exquisitely beautiful by their glassy texture, their often brilliant colours, and their power of giving out light or "phosphorescing" at night. They generally swim near the surface of the water, and they form a large portion of the diet of many marine animals.

Before leaving the Hydroid Zoophytes, we must notice that there are various little free-swimming and locomotive animals which are found in most seas, and which entirely resemble the free and active reproductive buds of the fixed Hydroids, so far as their actual form and structure are concerned, while their life-history is really a different one. The organisms in question are generally called Jelly-fishes or "Medusæ," and they constitute the group of the *Medusidæ* or *Hydromedusidæ*. As just remarked, these little creatures are, in actual structure, entirely similar to the free-swimming reproductive buds or "gonophores" of many of the fixed Hydroid Zoophytes, and each consists of a gelatinous, transparent, bell-shaped disc (fig. 23), by the contraction of which it drives itself gracefully through the water. From the centre of the lower surface of the swimming-bell there hangs a single polypite, with a mouth at its free end and a stomach in its interior. From the margin of the bell hang more or less numerous tentacles by which the animal captures its prey, and there are also certain brightly-coloured spots, which appear to be organs of vision. From the conspicuous position of these coloured spots on the edge of the disc, unprotected by any covering, the name of "naked-eyed" *Medusæ* was given to the group by Forbes.

The peculiarity about these "naked-eyed" Medusæ, by which they are distinguished from the "medusoids" of the fixed Hydroids, concerns their mode of *development*. In the case of the medusoid buds of the fixed Hydroids, as we have seen, the eggs which are produced are developed into the fixed plant-like colonies, from which the medusoids were originally detached, instead of giving rise to new medusoids. There is thus an "alternation of generations," the rooted colony developing free reproductive buds, the eggs of which become converted into colonies like the original parent. On the other hand, in the naked-eyed Medusæ now under consideration, the eggs produced by the little swimming Jelly-fish become directly developed into new Jelly-fishes, and they do not give origin to plant-like colonies, so that there is no alternation of generations. It is worthy of notice that a remarkable and interesting Medusa has recently been discovered to inhabit fresh water (the warm-water tanks of the Royal Botanical Society of London). With this exception, all the known members of the *Medusidæ* are confined to salt water.

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[1] The name of "Medusæ" or "Medusoids" is given to the Jelly-fishes on account of a fancied resemblance afforded by the tentacles which hang from the edge of the bell to the snaky hair of Medusa.

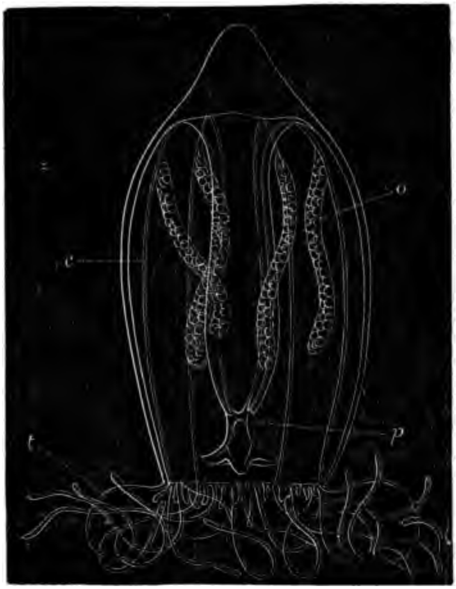

Fig. 23.—A naked-eyed Medusa (*Trachynema*), female, enlarged. *p* Central polypite; *t* One of the tentacles; *c* One of the canals carrying nutritive fluid through the body; *o* One of the ovaries.

CHAPTER IV.

SIPHONOPHORA, LUCERNARIDA, HYDROCORALLINÆ.

Sub-Class II. Siphonophora.—Having treated the Hydroid Zoophytes at considerable length, the remaining members of the *Hydrozoa* must be very briefly passed over. In the present group we have a number of animals which are known as "Oceanic Hydrozoa," as they are not fixed to one place, but are found swimming or floating in the open ocean, far from land. They are delicate and transparent, often brightly-coloured organisms, and are always composite; some of them are furnished with swimming-bells, by the contractions of which they propel themselves freely through the water. Others are buoyed up by an air-receptacle, and float idly at the mercy of the waves and the wind. They are most abundant in the warmer seas of the globe.

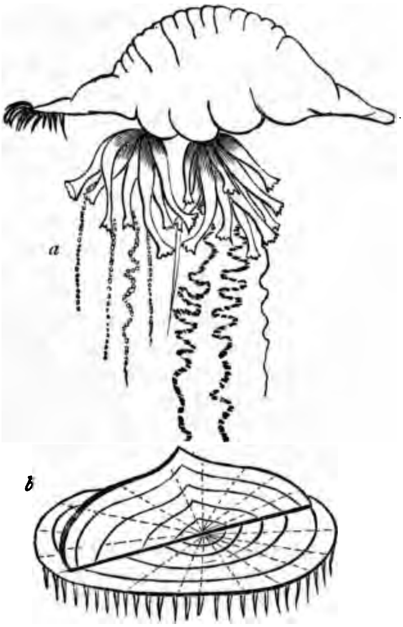

Fig. 24.—*a* Portuguese Man-of-war (after Huxley); *b* *Velella* (after Gosse).

Good examples of the Oceanic Hydrozoa are to be found in the singular organisms known as the Portuguese Man-of-war (*Physalia*), and the Sallee-man (*Velella*).

In the Portuguese Man-of-war (fig. 24, *a*) the animal floats near or at the surface of the sea by means of a long spindle-shaped "float," which is filled with air. The float may be several inches in length, and from its under surface hangs a series of polypites, with highly contractile tentacles, and reproductive organs. The tentacles are often of great length, and have the power of stinging very severely, from the presence in them of numerous thread-cells. In *Velella* (fig. 24, *b*) we have an animal nearly allied to *Physalia*, but having a flattened, disc-like float, upon the upper surface of which is carried a vertical triangular crest which officiates as a sail. From the under surface of this hang numerous tentacles and small reproductive processes, with a single large central polypite. It is of a beautiful bluish colour and semi-transparent, and, like the Portuguese Man-of-war, it is occasionally driven upon our coasts, though really a native of warmer seas than ours.

SUB-CLASS III. LUCERNARIDA.—Very various organisms are included under this head, but it is only possible to notice those which were formerly termed "hidden-eyed" *Medusæ*, and which are familiarly known as Sea-nettles or Sea-blubbers. Every seaside visitor is familiar with the great circular discs of jelly which are left upon the sands by the retreating tide during the summer months; many must have noticed them slowly flapping their way through the water by means of their large transparent discs; and a few may have found by painful experience that some of them can sting severely if incautiously handled. They all present a decided external resemblance to the little "naked-eyed" *Medusæ*, but they differ considerably amongst themselves both in their actual nature and in anatomical structure. Some of them produce eggs which are developed into organisms resembling themselves; but most of them are now known to be the free-swimming reproductive buds of minute, rooted *Hydrozoa*. It will be sufficient here to describe briefly the life-history of one of the British examples of these latter.

If we commence with the egg of one of these singular organisms, we find that it gives origin to a minute ciliated body (fig. 25, *a*), which swims about actively by means of its cilia. This little body ultimately fixes itself, becomes trumpet-shaped, and develops a mouth and tentacles at its expanded extremity, when it is known as the "Hydra-tuba," from its resemblance in shape to the Fresh-water Polype or *Hydra* (fig. 25, *b*). The Hydra-tuba is only about half an inch in height, and it can form large colonies by budding, but it cannot produce eggs.

Under certain circumstances, however, the Hydra-tuba enlarges, and, after a series of preliminary changes (fig. 25, *c*, *d*), divides by transverse cleavage into a number of segments, each of which becomes detached and swims away. The liberated segments have the structure of "hidden-eyed" *Medusæ*, and increase rapidly in size, becoming, not only comparatively, but often actually, gigantic. These enormous reproductive bodies lead an active and independent life till they are able to develop eggs in their interior, when they die. The fertilised egg, however, develops itself, not into the monstrous organism by which it was produced, but into the little fixed Hydra-tuba, from which the generative segment was originally given off.

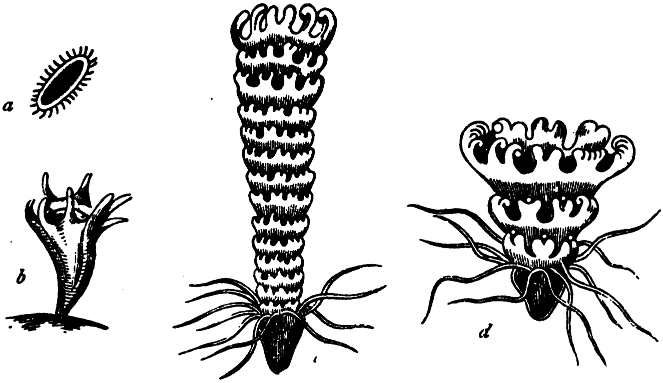

Fig. 25.—Development of one of the *Lucernarida* (*Aurelia*). *a* Free-swimming ciliated embryo; *b* Hydra-tuba; *c* Hydra-tuba undergoing transverse cleavage; *d* The same with the cleavage further advanced.

The Sea-blubbers, as already remarked, present a decided superficial resemblance to the "naked-eyed" *Medusæ*, or true Jelly-fishes; but they may be distinguished by various characters. Amongst the more striking points of difference may be mentioned the much greater size of the Sea-blubbers, the absence of any membrane or "veil" at the mouth of the swimming-bell, and the fact that the coloured eye-spots are protected and hidden from view by a sort of hood.

The great Sea-blubbers (fig. 26) may be found by thousands round our own coasts in the summer months, and they occur even in the open ocean hundreds of miles away from the nearest land. As seen when stranded on the shore, they are little more than unsightly lumps of jelly; but they are objects of great beauty as seen moving slowly through the calm water of some land-locked bay by the regular pulsations of the transparent umbrella or swimming-bell. Behind them they trail their long tentacles, which, as well as their bodies, are armed with innumerable thread-cells, and serve as a fatal net for any of the smaller marine animals which may happen to be in the way. Indeed, many of the Sea-blubbers can very unpleasantly affect man himself, producing an irritation very similar to that caused by nettles, and sometimes giving rise to very alarming symptoms. The lips of the central polypite are produced into long lobed processes, four in number, which extend far below the margin of the disc; and the reproductive organs are usually of some bright colour, and form a conspicuous cross when we look at the swimming-bell from above. As regards their actual texture, the Sea-blubbers are little more than "organised sea-water," but they often attain an almost fabulous size. Thus, Agassiz notes the occurrence of a Sea-blubber in which the swimming-bell was seven feet in diameter, and the tentacles more than fifty feet in length.

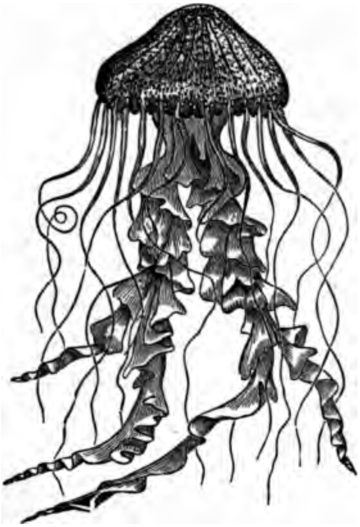
Fig. 26.—Sea-blubber (*Chrysaora hysoscella*), after Gosse.

Sub-class IV. Hydrocorallinæ.—Finally, we may first notice that there are certain *Hydrozoa* which develop a hard skeleton of lime, the outward appearance of which is exceedingly like that of many corals. The forms which produce a calcareous skeleton of this kind are known as "Hydrocorallines;" and the most important of them are the Millepores (*Millepora*), which play a considerable part in the formation of the coral-reefs of the West Indies and Pacific. The skeleton of *Millepora* (fig. 27) is calcareous, and generally much branched and divided, its general texture being spongy. Its surface (fig. 27, C) shows two series of openings, one large and the other small, the latter being the most numerous. The same double series of differently-sized tubes is shown in vertical sections of the skeleton (fig. 27, B), and these also show that the large tubes are crossed by numerous transverse plates or partitions. When examined during life, it is found that we have to deal in *Millepora* with a fixed colony consisting of two different sets of polypites. The polypites which inhabit the large tubes are short and have a mouth, surrounded by short tentacles, and a distinct stomach. On the other hand, the small tubes of the skeleton of *Millepora* lodge long, feeler-like polypites, which have numerous short tentacles, but are destitute of a mouth, the function of these being apparently to supply food to the larger mouth-bearing polypites. How *Millepora* reproduces itself is not yet known.

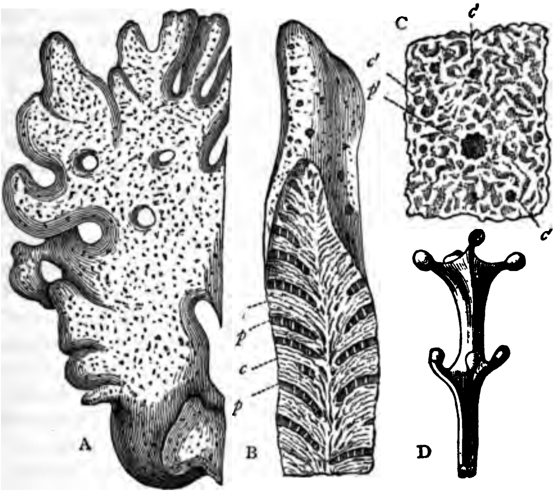

Fig. 27.—A, Part of the skeleton of *Millepora*, of the natural size. B, Part of the same cut open vertically, to show the large and small tubes of the skeleton. C, Part of the surface of the same, enlarged, showing the mouths of the large and small tubes (*p'* and *c'*). D, A single one of the small polypites enlarged.

CHAPTER V.

CLASS II. ACTINOZOA.

THE second great class of the *Cœlenterata* is that of the *Actinozoa*, comprising the Sea-anemones and their allies, the Corals, the Sea-pens, the Sea-shrubs, and various other organisms. They are distinguished from the *Hydrozoa* by the fact that the mouth opens into a distinct digestive sac or stomach (fig. 28), which in turn communicates by a wide opening with the cavity of the body. The body-walls are separated from the walls of the stomach by a space, which is divided into a number of chambers by a series of partitions which are known as the "mesenteries." The body-cavity, subdivided into compartments by the vertical plates just mentioned, is filled partly with sea-water, and partly with the products of digestion derived from the stomach. The reproductive organs differ from those of the *Hydrozoa* in being situated in the interior of the body. In the other essential details of their structure, the *Actinozoa* do not differ from the *Hydrozoa*. The body is composed of two fundamental layers, an outer and an inner, and thread-cells are usually present in abundance. There are but occasionally traces of a nervous system; and in none is there any circulatory system. Distinct reproductive organs are always present, and true sexual reproduction occurs in all. In many cases, however, the *Actinozoa* exhibit budding or cleavage; the result being the formation of compound organisms or colonies. In these cases—as in most of the Corals—the separate beings produced by either of these methods are termed "polypes"—the term "polypite" being exclusively confined to the *Hydrozoa*. Where, however, the *Actinozoön* consists of but a single being, it is also termed a polype, as in most of the Sea-anemones. Most of the *Actinozoa* are permanently fixed, as the greater number of the Corals; some, like the Sea-anemones, possess a limited amount of locomotive power; and one order, the *Ctenophora*, is composed of active free-swimming organisms. Some are unprovided with any hard structures or supports, as the Sea-anemones and *Ctenophora;* but a great many produce a calcareous or horny skeleton or framework, which is known as the "coral" or "corallum."

The *Actinozoa* are divided into the three living orders of the *Zoantharia*, *Alcyonaria*, and *Ctenophora*, each of which must be briefly noticed.

ORDER I. ZOANTHARIA.—The *Actinozoa*, comprised in this order, are distinguished by having *smooth*, *simple*, *usually numerous tentacles*, *which*, *like the mesenteries*, *are in multiples of five or six*. The best known and most important members of the order are the Sea-anemones and the "reef-building" Corals.

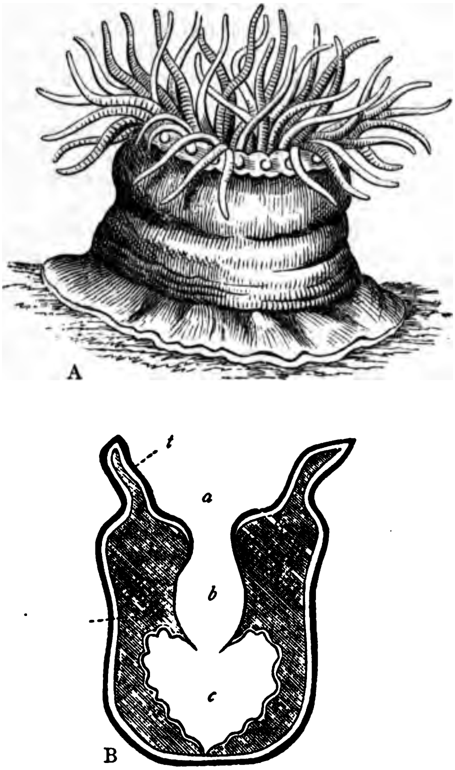

Fig. 28.—A, *Actinia mesembryanthemum*, one of the Sea-anemones (after Johnston). B, Section of the same, showing the mouth (*a*), the stomach (*b*), and the body-cavity (*c*); the dark and light lines show the two integuments of the body.

The Sea-anemones (*Actinidæ*) occur on every coast, and are familiar to every visitor at the seaside. The body (fig. 28, A) is in the form of a truncated cone or short cylinder, and is of a soft leathery consistence. One end of the body forms a kind of sucker, by means of which the animal can fix itself at pleasure to any solid body; and at the opposite end is the mouth. The mouth is surrounded by a flat space without appendages, and this, in turn, is surrounded by numerous simple smooth tentacles, arranged in alternating rows. The tentacles are hollow, and can, as a general rule, be both protruded to a great length and again retracted. The mouth opens into a wide and capacious stomach, which extends about half-way between the mouth and the base, and opens below into the body-cavity (fig. 28, B). The wide space between the stomach and body-walls is divided into a number of chambers by vertical plates or "mesenteries," to the faces of which the reproductive organs are attached. The Sea-anemones are mostly found between tide-marks in rock-pools, or on ledges of stone, adhering to solid objects by means of the sucker-like base. They are not, however, permanently fixed, but can remove their place at will; and some forms appear to be permanently free. They are often of the most brilliant colours, and when they are perfectly expanded, they fully deserve the name of "Animal flowers" often applied to them. They can very readily be kept in confinement, and are amongst the most beautiful objects of the aquarium. They are tolerably voracious in their habits, and most of the larger kinds will willingly take raw meat, and thrive upon it. How long their usual term of life, in a state of nature, may be, is uncertain; but they have been known to live in confinement for a very long period. The most striking example of this is that of an old *Actinia mesembryanthemum*, which was originally taken from a rock-pool at North Berwick by Sir John Dalzell in August 1828, and which still (1880) survives. Not only is "Grannie," as this ancient Anemone is familiarly called, in perfect health, in spite of its being over fifty years old, but it has, on various occasions, given birth to a numerous progeny. Some of the Sea-anemones have little coloured spots at the bases of the tentacles, which are apparently in connection with a rudimentary nervous system, and appear to be imperfect eyes. The body-walls of the Sea-anemones are very muscular, and they not only adhere with great tenacity by their sucker-like base, but have the power of altering their form to a wonderful extent. When irritated or alarmed, they contract themselves into a shapeless lump; but when unrestrained by fear or in search of food, they fill the body-cavity and tentacles with sea-water, and expand themselves to three or four times their former dimensions.

The great group of the *Corals* comprises a number of the most beautiful and interesting organisms, which can only be very shortly noticed here.

The simplest forms of Corals exactly resemble the Sea-anemones in structure, but differ in having the power of producing in their interior a hard calcareous structure or "coral." Most of the Corals, however, are less simple than this, for they form extensive colonies by means of budding or cleavage. In order, therefore, to form a clear conception of one of these compound Corals, we must imagine a great number of polypes, like the Sea-anemones in actual structure, but smaller as a rule, united together by a common flesh, whilst the whole colony has the power of secreting a calcareous framework or skeleton. If, therefore, we examine the skeleton or "coral" of one of these compound organisms, we see a number of little cups (fig. 29, *a*), each of which represents the skeleton of a single polype, the whole united together by calcareous matter deposited by the common trunk or "cœnosarc" of the polypes.

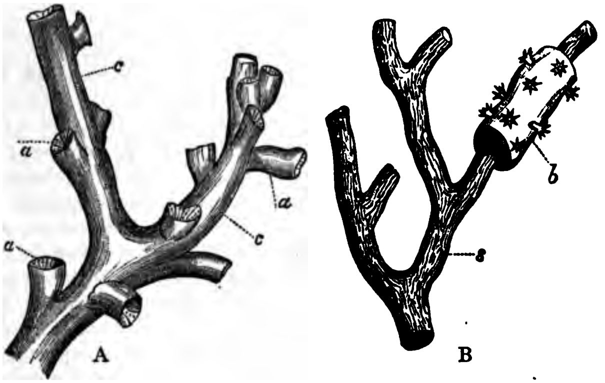

Fig. 29.—A, Portion of a compound Coral (*Dendrophyllia*), showing the cups (*a a*) produced by the separate polypes, united by a common calcareous tissue. B, Portion of a branched Coral (*Gorgonia*), showing the hard horny skeleton in the centre, surrounded by a fleshy bark or rind, in which the little polypes are embedded.

As just remarked, some of the Corals are simple, whilst others are composite, and in both cases the skeleton is usually of great beauty. The simple Corals are generally of small size, and are found in most seas, for the most part inhabiting deep water. The compound Corals may attain enormous dimensions, since they are formed by the combined exertions of a vast number of zoophytes working together, and forming a common skeleton (fig 30). The larger compound Corals are, however, not found in perfection except in warm seas. In the oceans which lie within a certain distance of the equator on either side, the compound Corals attain a most luxuriant growth, and they give rise to the structures known as "coral-reefs." A coral-reef is a great mass of coral, it may be hundreds of miles in length, composed of the aggregated skeletons of various species of Corals. The reef-building zoophytes do not live in water deeper than about one hundred and eighty feet, so that all reefs are commenced in shallow water, and it is usually only the upper portion of the reef that is actually alive. The living part of the reef is like a submarine forest, tenanted by countless animals which either seek protection in its innumerable recesses and crevices, or have recourse to it for the purpose of obtaining food. As viewed, therefore, through the transparent waters of the tropics, we may well believe that a coral-reef presents us with a scene of the most marvellous beauty, in which we find it difficult to decide whether admiration is more justly bestowed on the graceful and elegant forms of the corals, or the gorgeous colours of the polypes.

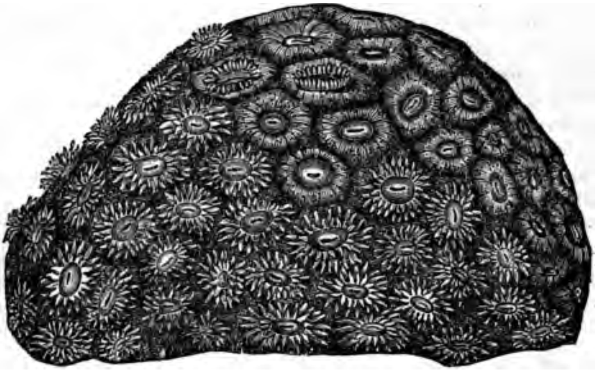

Fig. 30.—A compound Coral (*Astræa pallida*) in its living state (after Dana).

In the seas in which they more especially flourish—namely, the Pacific and Indian Oceans, and the Caribbean Sea—the reef-building polypes are gradually accumulating vast masses of calcareous matter which will ultimately form islands and continents. Even at the present day, coral-reefs are often converted into dry land, and become the home of animal and vegetable life. It is true that the rate of growth of a coral-reef is very slow, and the individual workers at the reef are very small; but the aggregate results produced are on a scale of the most striking magnitude. Three principal kinds of reefs have been distinguished by Mr Darwin in his well-known work on coral-reefs :—

1. *Fringing-reefs.*—These are reefs of comparatively small size surrounding islands or skirting continents, and having no great depth of water either outside or inside.

2. *Atolls.*—These are reefs which form more or less complete rings, circular or oval in shape, and enclosing a central lagoon without any land (fig. 31).

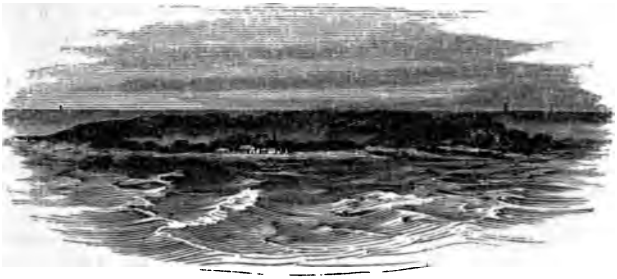

Fig. 31.—Whitsunday Island, one of the "Atolls" of the Pacific Ocean.

3. *Barrier-reefs.*—These surround islands or skirt continents, and differ from fringing-reefs chiefly in the great depth of the water outside, and the great comparative width of the channel inside between the reef and the land. Barrier-reefs are the most interesting of all the coral-reefs, and a few words may be said as to one of the best known, the great Barrier-reef of Australia. This colossal reef extends as a gigantic wall along the N.E. coast of Australia, from Breaksea Spit to Bristow Island, a length of over 1100 miles. During the whole of this course it keeps at a distance of some miles from the land, from which it is separated by a channel of smooth water, which has an average depth or from 20 to 30 fathoms. The average breadth of the reef itself is about 30 miles, and it has a superficial area of about 33,000 square miles. Its continuity is rarely broken by narrow channels which let in the water from

the sea outside, the depth of which, close to the reef, is from 500 to 1800 feet. The seaward face of the reef is constantly beaten by the most tremendous surf imaginable, produced by the sudden stoppage of the long rollers which come in from the open ocean; but the inner channel, being protected from these, is perfectly calm.

In an ordinary coral, whether simple or compound, we have to deal with a calcareous skeleton which is secreted within the tissues of the animal producing it, and which, therefore, always shows one or more "cups," with radiating partitions, corresponding in number to the polypes which compose the organism (fig. 29, A). In other cases, however, the coral (fig. 29, B) forms a hard central stem or axis, sometimes branched, sometimes unbranched, and composed either of horn or of lime, or of both, the soft parts of the animal, with the embedded polypes, surrounding the skeleton as the bark of a tree surrounds the central wood.

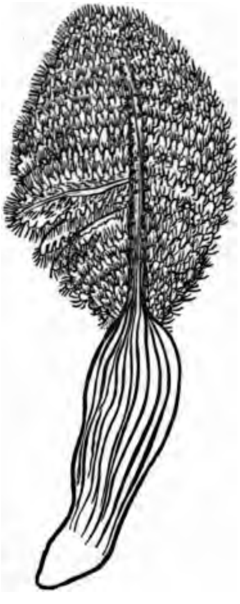

Fig. 32.—*Pennatula phosphorea* (after Johnston).

ORDER II. ALCYONARIA.—The second great order of *Actinozoa* is distinguished by the fact that the polypes are furnished with *fringed* tentacles, and that these, as well as the mesenteries, are always some multiple of *four* in number (usually eight). Several of the Alcyonarian Polypes are more or less familiarly known, such as the Dead-men's-fingers (*Alcyonium*), the Organ-pipe Coral (*Tubipora*), and the Sea-rod (*Virgularia*); but it will be enough to notice the Sea-pen (*Pennatula*) and the Red Coral (*Corallium rubrum*).

The Sea-pen or Cock's-comb (fig. 32) is not uncommonly found in our seas, on muddy bottoms, in moderately deep water. It varies from 2 to 4 inches in length, and appears to live with its lower extremity sunk in the mud of the sea-bottom. It presents a kind of resemblance to a feather, its lower portion being naked, whilst the upper part is fringed with lateral processes on both sides. The lower smooth portion is fleshy, and is strengthened by a long, slender, internal skeleton or coral. The lateral fringes of the upper portion carry numerous small polypes. The general colour of *Pennatula* is deep reddish purple, passing into orange yellow at the base. Our British species phosphoresces brilliantly when irritated.

The best known of the *Alcyonaria* is the Red Coral of commerce (*Corallium rubrum*), which is largely imported for ornamental purposes from the Mediterranean. In this species (fig. 33) there is an internal skeleton, in the form of a bright-red, finely-grooved coral, of great density, and composed of carbonate of lime. The coral is usually more or less repeatedly branched, and is invested by a bright-red bark or rind, which is studded with numerous little apertures. From these openings the polypes can be thrust out at will, each being of a milk-white colour, and having eight fringed tentacles. The entire fleshy bark is excavated into a number of communicating canals, with which the digestive cavities of the polypes are connected, the whole system being filled with a nutritive fluid, known as the "milk."

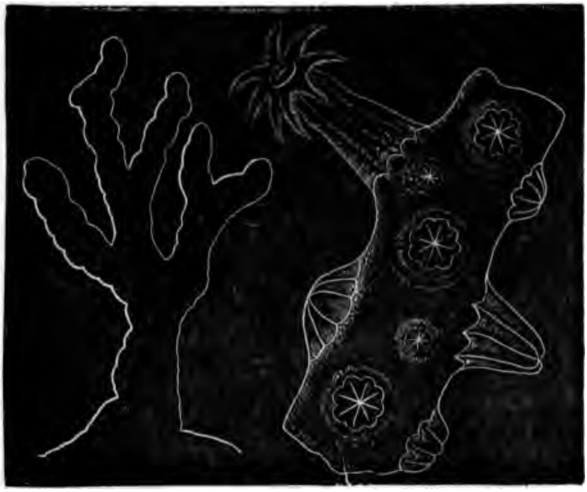

Fig. 33.—Red Coral (*Corallium rubrum*) of the natural size, and a portion enlarged.

ORDER III. CTENOPHORA.—The last order of living *Actinozoa* is that of the *Ctenophora*, of which *Pleurobrachia* (fig. 34) may be taken as the type. This beautiful little organism is found, like all the other members of the order, swimming in the open ocean. The organs by which locomotion is effected are numerous transverse rows or comb-like plates of cilia, arranged in longitudinal bands; hence the name *Ctenophora* (Gr. *kteis*, a comb; *phero*, I bear). The body of *Pleurobrachia* is melon-shaped, gelatinous, transparent, and colourless, and exhibits two poles, at one of which is placed the mouth. Besides the ciliated bands there are two very long and flexible tentacles, which can be instantaneously thrust out, and as instantaneously withdrawn, at the will of the animal. The mouth opens below into a spindle-shaped stomach, which is in connection with a complicated canal system, which is ciliated internally, and is filled with a nutrient fluid. Near the opposite pole of the body to the mouth is a little vesicle or sac, believed to be a rudimentary organ of hearing, and placed upon this is a little mass which is generally believed to be of a nervous nature. If so, this is, amongst Cœlenterate animals, one of the comparatively

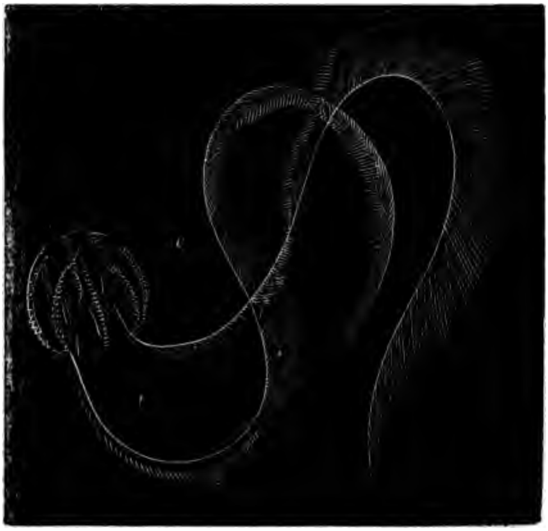

Fig. 34.—Adult of *Pleurobrachia rhododactyla*, in a natural attitude and of the natural size. (After A. Agassiz.) *c* One of the ciliated bands or ctenophores; *t* One of the tentacles.

few cases in which we meet with an anatomically distinct nervous system.

Pleurobrachia is of very common occurrence in our seas, especially during the summer months, and can readily be obtained with the towing-net. When taken out of the water, it looks like a little shapeless lump of transparent, glassy jelly; but as viewed in its native element, it is an object of surpassing beauty, its bands of cilia reflecting all the hues of the rainbow, and its movements being of the most active and graceful description.

SUB-KINGDOM III.—ECHINODERMATA.

CHAPTER VI.

THE *Echinodermata*, including the Sea-urchins, Star-fishes, and their allies, form a very distinctly circumscribed group of the animal kingdom, and are, for the most part, obviously of the "Radiate" type, to use a now nearly obsolete term. They possess, as pointed out by Professor Huxley, certain remarkable relationships with some of the lower worms (*Scolecida*); and the distinguished naturalist just mentioned at one time included both these groups of animals in a common division, to which the name of *Annuloida* was applied. Upon the whole, however, it would appear preferable to consider the *Echinodermata* as an independent primary group or "sub-kingdom," and to regard the Scolecid worms as being one of the divisons of the great sub-kingdom of the Annulose animals.

Taking this view of the subject, the sub-kingdom *Echinodermata* contains the Sea-urchins, Star-fishes, Sand-stars, Feather-stars, Sea-cucumbers, &c., and derives its name from the prickly nature of the skin in most of the animals which belong to it (Gr. *echinos*, hedgehog; *derma*, skin). In almost all of the Echinoderms the skin has the power of secreting lime, but the extent of this power varies much. When adult, they all show a more or less distinctly ray-like or "radiate" arrangement of their parts, which is most conspicuous in the star-shaped Star-fishes and Sand-stars, but can be detected in all the members of the class. When young, however, they almost always exhibit more or less of what is called "bilateral symmetry"—that is to say, they show similar parts on the two sides of the body. In all there is a "water-vascular system" of canals, which is termed the "ambulacral system," generally communicates with the exterior, and is mostly used in locomotion. An alimentary canal is always present, and is always completely shut off from the general cavity of the body. There are always distinct organs of reproduction, which are almost always placed in different individuals, so that the sexes are distinct. The nervous system is in the form of a ring, surrounding the gullet, and sending branches in a radiating manner to different parts of the body.

The *Echinodermata* are divided into five recent orders and two extinct, of which only the former need be considered here :—

1. *Echinoidea* (Sea-urchins).
2. *Asteroidea* (Star-fishes).
3. *Ophiuroidea* (Brittle-stars).
4. *Crinoidea* (Feather-stars).
5. *Holothuroidea* (Sea-cucumbers).

ORDER I. ECHINOIDEA.—The Sea-urchins or Sea-eggs, which form this order, vary in form from a globe to a flattened cake, and are characterised by having the body encased in a "test" or shell, composed of numerous calcareous plates, which (with few exceptions) are immovably jointed together so as to form a kind of box (fig. 35).

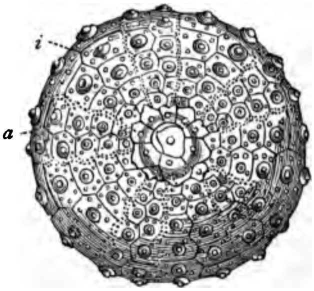

Fig. 35.—Test of *Strongylocentrotus Drobachiensis*, a regular Sea-urchin, viewed from above, the spines being removed. *a* Ambulacral area; *i* Inter-ambulacral area. (After A. Agassiz.)

The "test" or shell of a Sea-urchin (fig. 35) is mainly composed, in all living forms, of twenty rows of calcareous plates, arranged in ten alternating zones, each zone composed of two rows of plates. In five of these zones (fig. 35 *i* and 36 *a*) the plates are of large size, and are not perforated by any holes. These are termed the "inter-ambulacral areas." In the other five zones (fig. 35 *a* and 36 *b*) the plates are much smaller, and are perforated by little holes, through which can be protruded the delicate suctorial tubes, which are known as the "tube-feet." These zones are called the "ambulacral areas." The main part of the test is made up of these ten zones; but besides these there are other plates developed in the leathery skin round the mouth and vent. The most important of these supernumerary plates form a kind of disc, which is placed at the summit of the shell, and generally has the opening of the vent in its centre. This disc (fig. 36, 2) is composed of ten plates, of which five are perforated for the ducts of the reproductive organs, and five, of smaller size, carry each an eye-spot. One of the genital plates (*f*) is also larger than the others, and carries a spongy mass—the so-called "madreporiform tubercle," which protects the entrance of the ambulacral system. Lastly, the whole of the test is covered with numerous tubercles of different sizes, which carry longer or shorter spines or prickles, from the presence of which the name of "Sea-urchin" is derived. The spines (fig. 37) vary in length in different species, can be moved at the will of the animal, and doubtless act both as defensive weapons and as locomotive organs.

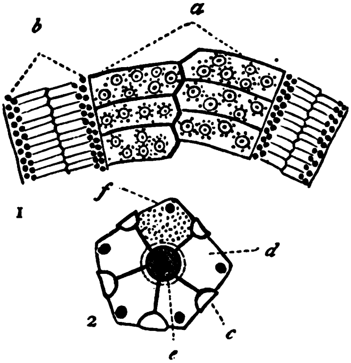

Fig. 36.—Morphology of Echinoidea. 1. Portion of the test of a Sea-urchin (*Galerites*), enlarged, showing the ambulacral areas (*b*) and inter-ambulacral areas (*a*). 2. Genital disc of a Sea-urchin (*Hemicidaris*) enlarged: *c* Ocular plate; *d* Genital plate; *e* Anal aperture; *f* Madreporiform tubercle. (After Forbes.)

Locomotion is mainly effected in the Sea-urchins by a singular system of contractile tubes, which are known as the "tube-feet," and which are appendages of the water-vascular system. These tube-feet are very numerous, and they can be protruded at will from the little holes in the "ambulacral zones." Each terminates in a little sucker or disc, and by the combined action of numbers of these working together the Sea-urchin drags its ponderous body along. Water is admitted to the tube-feet by five radiating canals, which run along the five ambulacral zones, and which spring from a circular vessel round the gullet. This, in turn, receives water by means of a canal which opens at the surface by the "madreporiform tubercle."

The mouth of the Sea-urchin is armed with a curious apparatus of calcareous teeth, and conducts into a long and convoluted alimentary canal, which is attached to the interior of the shell by a delicate membrane, and terminates in a distinct vent. There are no very definite organs of respiration, and this function appears to be discharged partly by certain portions of the ambulacral system, and partly by the ciliated surface of the digestive canal and mesentery. The nervous system of the Sea-urchin consists of a pentagonal ring, surrounding the gullet, and sending five radiating branches along the five ambulacral areas. The young *Echinus* is at first a free-swimming ciliated organism, bilaterally symmetrical, and so unlike the adult that, in its later stages, it was described as a distinct animal, under the name of *Pluteus*. The extraordinary point, however, about its development is, that the young *Echinus* is developed out of only a *portion* of the *Pluteus*, the greater part of which is absorbed or cast away as useless.

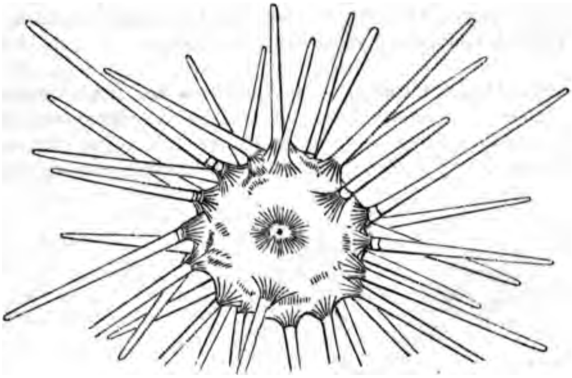

Fig 37.—*Cidaris papillata* (after Gosse).

The Sea-urchins are all inhabitants of the sea, and abound more especially in shallow water, though some species extend to great depths. They are commonly found in great numbers together, and as many as twenty thousand specimens of a single species have been brought up in one haul of the dredge (Sir Wyville Thomson). The exact mode of life differs in different species, some crawling about freely on the sea-bottom, others burying themselves in sand or mud, and others boring regular holes or burrows in the rock, in which they live. Locomotion is effected, with greater rapidity than we should imagine possible, partly by means of the suctorial tube-feet, and partly by the spines. The tube-feet can be distended with water, till they reach beyond the ends of the longest spines, and their suckers are thus enabled to take hold of foreign objects. The spines, again, are under the control of the animal, and can be erected and depressed at will. The rudimentary eyes appear to give the animal some power of vision, as Sea-urchins have been noticed to direct their spines towards any object threatening them. Those species, which, like the common Heart-urchins, live buried in the sand or mud, are sluggish animals, and feed upon the organic matter contained in the mud around them. In various localities, the larger Sea-urchins are eaten by man, and are, indeed, considered as rather a delicacy.

ORDER II. ASTEROIDEA.—Having described the anatomy of the Sea-urchins pretty freely, it will not be necessary to do more than very briefly indicate the more important characters of the remaining orders. The order *Asteroidea* comprises only

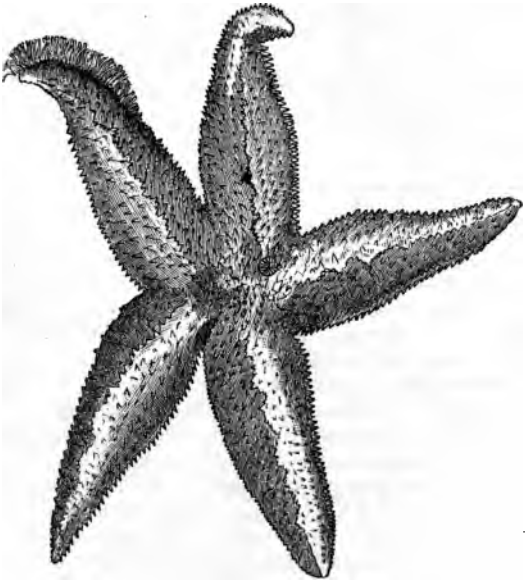

Fig. 38.—The common Star-fish (*Uraster rubens*), natural size, viewed from above.

the true Star-fishes, which consist of a central disc surrounded by a number of rays or arms, which are generally five in number, but may be considerably more numerous. The arms are direct prolongations of the body (fig. 38), contain prolongations of the stomach, and are deeply grooved on their under surface for the radiating vessels of the water-vascular or ambulacral system.

In their internal anatomy, the Star-fishes do not differ very much from the Sea-urchins. The body, however, is now no longer encased in an immovable box formed of calcareous plates firmly joined together, but the skin is of a leathery nature, and is furnished with an enormous number of little detached grains, plates, and spines of carbonate of lime. Locomotion is effected much as in the Sea-urchins; but the ambulacral tube-feet are arranged in rows, in grooves which run along the under surface of each arm and meet at the mouth. On the upper surface is the "madreporiform tubercle," and also the vent, when this is present. The mouth is placed in the centre of the lower surface, and is destitute of teeth. From the stomach proceeds a series of much-branched membranous sacs, two of which are prolonged into each of the arms. The nervous system and reproductive organs have much the same arrangement as in the Sea-urchins.

The commoner Star-fishes have a small disc with long finger-like rays, which are properly five in number (fig. 38). In the Sun-stars (*Solaster*) the disc is broad, and is furnished with from twelve to fifteen short rays. In the Cushion-stars (*Goniaster*) the body is in the form of a five-angled disc, more or less flattened on both sides, the rays only being indicated by the ambulacral grooves on the lower surface.

The common British Star-fish (*Uraster rubens*, fig. 38) is found on almost every portion of our coasts, and often in the greatest profusion. It is usually from three to six inches across, and of a reddish, yellowish, or orange colour. It is very voracious, and feeds largely upon shell-fish, seeming to suck the animal out of the shell by means of the protrusible stomach, or swallowing the shell whole. It has normally five arms, but some of these are often broken off, and the animal has the power of slowly reproducing them; so that it is very common to find individuals of the most grotesque shapes, owing to more or fewer of the arms having been lost, and being in process of regeneration. The common Sun-star (*Solaster papposa*), with its broad disc and its twelve or more arms, and its brilliant red or purple upper surface, is one of the handsomest of our native species, and is quite common on many parts of our coasts.

ORDER III. OPHIUROIDEA.—The Sand-stars and Brittle-stars compose this order, and are very closely allied to the true Star-fishes, especially in their star-like form. The body (fig. 39) consists of a central disc giving off radiating arms, which are five in number, and may be simple or branched, but which differ from the arms of the true Star-fishes in not containing any prolongations from the stomach, and in not being grooved for the ambulacral tube-feet. All the internal organs are contained within the disc, and none of them pass into the arms, except the nerve-cords and the ambulacral vessels. The mouth is placed on the under surface of the disc, and conducts into a globular stomach; but an intestine and vent are wanting.

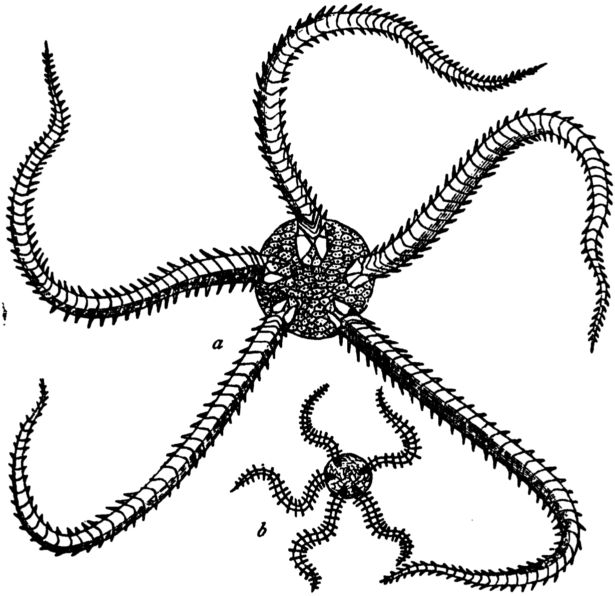

Fig. 39.—*a Ophiura texturata*, the common Sand-star; *b Ophiocoma neglecta*, the grey Brittle-star. (After Forbes.)

The habits of the Brittle-stars and Sand-stars are various, but many of them may be found at low water on our own shores, in rock-pools or under stones. Others inhabit the deep sea, extending to very great depths. Unlike the true Star-fishes, the Brittle-stars have no tube-feet, or locomotive suckers, and they consequently move about by means of their long, flexible, spiny arms, by which they are enabled to creep about with great activity. The name of "Brittle-stars" is given to these beautiful creatures from the extraordinary readiness with which the arms break up into pieces, if the animal be laid hold of. They have, however, like the Star-fishes, the power of reproducing their lost arms.

ORDER IV. CRINOIDEA.—The members of this order are distinguished by the fact that they are fixed, during the whole or a portion of the life of the animal, to submarine objects by means of a jointed flexible stalk or column. As an example of this order we may take the Feather-star (*Comatula*), which is found on various parts of our coasts. In its adult state, *Comatula* (fig. 40, *a*) does not differ much in appearance from an ordinary Brittle-star. It consists of a central body or disc, which gives off five arms, which divide directly after their origin into two branches, so that ultimately ten long and slender arms are produced. The rays carry slender processes on both sides, giving the whole arm the feather-like appearance from which the popular name is derived. When young, the *Comatula* differs so much from the adult, that it was originally described as a distinct animal. It consists (fig. 40, *b*) of a little

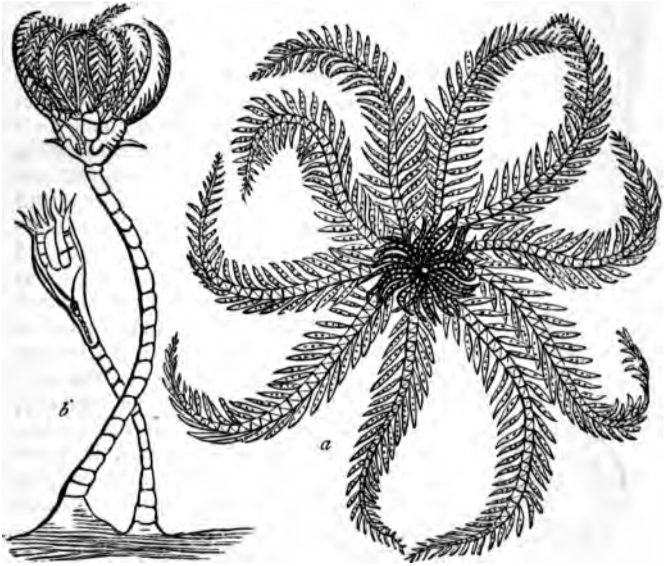

Fig. 40.—*a* Adult *Comatula*; *b* Young *Comatula* supported on its jointed stalk. (After Forbes.)

cup-shaped disc with ten radiating fringed rays, the whole supported on a little jointed stalk, by which it is fixed to some solid object. When sufficiently matured, the body drops off its stalk and develops into the free adult.

The stalked condition (fig. 41), which forms a mere temporary stage in the history of the Feather-star, is the permanent state of parts in a few living forms, and in many fossil species. The living stalked Sea-lilies are natives of deep water, and are for the most part exceedingly rare. The recent researches into the animals inhabiting the deeper recesses of the ocean have brought to light several new stalked Crinoids; but even now only a few species are known. They are amongst the most elegant and graceful of marine animals, their cup-shaped and tesselated bodies being fringed above with a crown of feathery arms, and supported below by a long and flexible stalk composed of numerous separate pieces or joints. The fossil stalked Crinoids are very numerous, and show that this group of animals must have abounded greatly in the older oceans. Most of the "Stone-lilies," as the fossil Crinoids are often called, are very beautiful, and they are of great importance geologically, whilst they have even an industrial value. Thus, whole beds of limestone, in more than one formation, are almost entirely composed of the broken stems of these animals, and many ornamental marbles owe their beauty to the same cause.

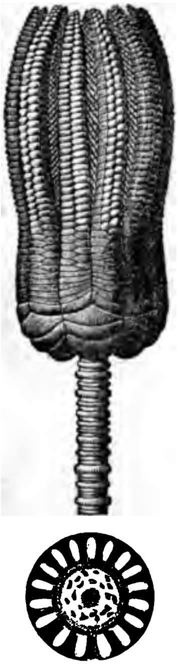
Fig. 41.—The "Lily-encrinite" (*Encrinus liliiformis*), a fossil stalked Crinoid. The lower figure shows one of the joints of the stalk.

ORDER V. HOLOTHUROIDEA.—Almost all the members of this order are more or less worm-like in form, and they are commonly known as "Sea-cucumbers." In them, the power of secreting calcareous matter is greatly reduced, the skin being simply furnished with scattered grains and spines of this material. They move about by the alternate contraction and extension of their bodies, by anchor-shaped spicules of lime in the skin, or by ambulacral tube-feet which can be thrust out through the integument. There is always a mouth, placed at one end of the body, and surrounded by a beautiful circlet of feathery tentacles; and there is always a distinct vent at the opposite end of the body. In many cases the termination of the alimentary canal is furnished with two much-branched tubes, which are filled with sea-water from without, and are known as the "respiratory tree," as they are believed to act as breathing-organs.

The Holothurians are mostly little known, as they generally live in tolerably deep water. Some of the foreign forms are of a large size, and some are much sought after to supply the Chinese market, being considered a great delicacy in that country. Owing to their worm-like form (fig. 42, *a*) one has some difficulty at first sight in recognising any relationship between the Sea-cucumbers and Trepangs and the globular Sea-eggs, the radiated Star-fishes and Brittle-stars, or the flower-like Sea-lilies; nevertheless, all these forms are built upon the same fundamental type. The Sea-cucumbers are not elegant animals, especially as seen when thrown up on the shore by the sea or taken out with the dredge; and under the best of circumstances they are comparatively unattractive, and very sluggish in their movements. One of the chief points proving their relationship with the typical Echinoderms is their possession (in most instances) of locomotive suckers or tube-feet. These suckers, however, are very differently dis-

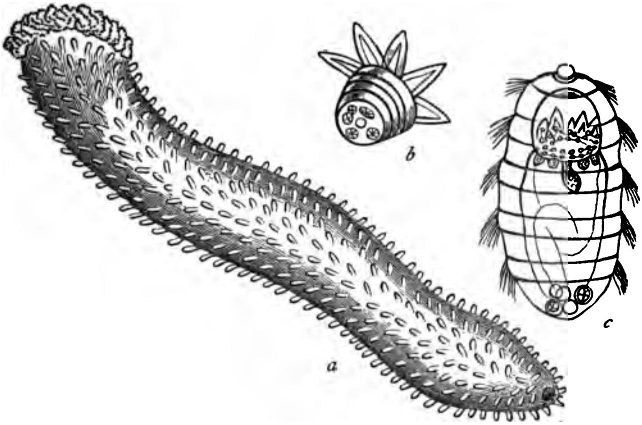

Fig. 42.—Annuloida. *a Holothuria tubulosa*, one of the Sea-cucumbers; *b* and *c* Young stages of the same (after Jones).

posed in different cases. Sometimes they are arranged in five regular rows, in accordance with the type so characteristic of the *Echinodermata*. At other times they are disposed irregularly over the whole body; and in some cases they occupy a kind of disc on the under surface of the body, the animal sometimes having its upper surface covered with tile-like plates, and thus resembling a kind of snail. The young Holothurians are very unlike the adults, and are active free-swimming little animals.

SUB-KINGDOM IV.—ANNULOSA.

CHAPTER VII.

GENERAL CHARACTERS AND DIVISIONS OF THE ANNULOSA. GENERAL CHARACTERS AND DIVISIONS OF THE SCOLECIDA.

SUB-KINGDOM ANNULOSA.—The Annulose animals are characterised by the possession of a body, which is usually elongated, and is never "radiate" or star-shaped in form. Generally, the body is more or less distinctly worm-like, and it is very usually divided into a greater or less number of distinct *rings* or segments, this character being the one which gives the name to the sub-kingdom (Lat. *annulus*, a ring). These rings are placed one behind the other, and if locomotive appendages are present, they are carried on the sides of the rings, and are therefore, "bilaterally symmetrical." A distinct nervous system is present, and consists either of one or two little nervous masses placed towards the head of the animal, or of a chain of nerve-centres, arranged in pairs, one pair corresponding with every ring of the body, and all the pairs being united by longitudinal cords. This knotted nerve-chain is always placed upon the lower or ventral surface of the body.

The sub-kingdom of the *Annulosa* comprises three principal groups of animals, which may be briefly defined as follows :—

I. SCOLECIDA.—This division includes the parasitic worms, the Wheel-Animalcules, and some animals related to these, and is characterised by the fact that the body is not really divided into regular and conspicuous segments, though the outer integument may exhibit superficial rings. A system of water-vessels is present, but is not concerned with locomotion. There is not a true heart, nor a proper blood-system ; and the nervous system consists of one or two masses placed in the head ; while the body is hardly ever provided with any appendages on its sides.

II. ANARTHROPODA.—The principal forms included in this group are the typical Ringed Worms (*Annelida*), in which the body is composed of a number (often almost indefinitely large) of similar or nearly similar segments, arranged one behind the other. The nervous system consists of a chain of ventral masses arranged in a double cord; and there is not a true blood-system, with a distinct heart and blood-vessels. The body very generally carries lateral and symmetrically-placed locomotive appendages, but these are never distinctly jointed or articulated to the body, the name of the division being in allusion to this fact (Gr. *a*, without; *arthros*, joint; *podes*, feet).

III. ARTHROPODA.—This division of Annulose animals includes the Crustaceans (Lobster, Crab, Barnacle, &c.), the Arachnidans (Spiders and Scorpions), the Myriapods (Centipedes and Millepedes), and the Insects. In all these the body (fig. 43) is composed of a series (usually definite) of distinct rings or segments, arranged along a longitudinal axis, one behind the other. There is usually a true blood-system, and the heart is placed towards the back of the animal. The nervous system consists typically of a double chain of nervous masses, united by longitudinal cords, and placed on the lower or ventral surface of the body. Limbs or lateral appendages are almost always present, and these are distinctly jointed or articulated to the body.

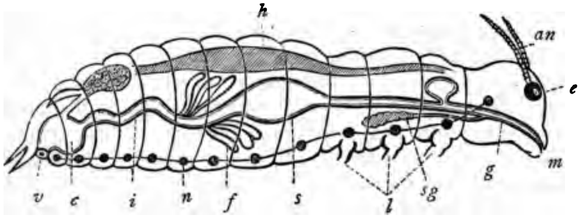

Fig. 43.—Diagram of the anatomy of an insect, showing the general characters of an Annulose animal. *an* Antennae; *e* Eye; *m* Mouth; *g* Gullet; *sg* Salivary gland; *s* Stomach; *f* Tubes supposed to represent the kidneys; *i* Intestine; *c* Chamber (cloaca) into which the intestine opens; *v* Vent; *h* Heart; *n* Nervous system; *l* Bases of the legs.

SCOLECIDA.

The *Scolecida* (Gr. *skoléx*, a worm), as we have just seen, form the first and lowest division of the sub-kingdom *Annulosa*, and are characterised by the possession of a water-vascular system of vessels, and a nervous system consisting of no more than one or two ganglia.[1] They differ from the *Echinodermata* in having no calcareous matter in the skin, and in exhibiting no traces of a radiate arrangement of their organs. Some are worm-like, but others are not, and one whole order is composed of microscopic organisms. Very many live parasitically within other animals, and these are often spoken of collectively as *Entozoa* (Gr. *entos*, within; *zoön*, an animal). These parasitic forms are often very degraded in structure, as they live without exertion on their own part, simply by imbibing the nutritive juices of their host through their delicate integument. The *Scolecida* are divided into the following seven groups or orders:—

1. *Tæniada* (Tape-worms).
2. *Trematoda* (Flukes).
3. *Turbellaria* (Planarians and Ribbon-worms).
4. *Acanthocephala* (Thorn-headed worms).
5. *Gordiacea* (Hair-worms).
6. *Nematoda* (Round-worms).
7. *Rotifera* (Wheel-animalcules).

ORDER I. TÆNIADA (Gr. *tainia*, a ribbon).—The family of the Tape-worms may well be illustrated by the commonest of the three Tape-worms of man, the *Tænia solium*. If we commence with the mature animal, we have a flattened tape-like body (fig. 44, 5), often many feet, or even yards, in length, and composed of a number of flattened joints (fig. 44, 4), all loosely united to one another. The entire organism is found inhabiting the alimentary canal of man, and it is not usual to find more than one in the same individual. The worm gradually tapers towards one extremity, till ultimately a point is reached, where the organism is firmly fixed to the mucous lining of the alimentary canal by means of a minute rounded "head" (fig. 44, 3). The "head" attaches itself by means of four suckers and a crown of little horny hooks. The head contains such nervous organs as exist, and is truly the animal, all the jointed tapelike body which follows it being really produced from the head by budding. The head, however, contains no reproductive organs, and the eggs are produced solely by the flattened joints. The eggs of the Tape-worm cannot be developed in the body of the man who is afflicted with the parasite, but they require to gain access to the body of some other warm-blooded animal, in order to develop themselves. To this end the ripe joints of the Tapeworm, laden with eggs, break off, are expelled from the body, and decay. The microscopic eggs, each with a little embryo in its interior (fig. 44, 1), are liberated, to be blown about by the wind or float in water, till they gain some situation where they may be swallowed by a pig. In the stomach of the new host the egg gives exit to a little embryo, which bores its way into the muscles, or into some solid organ, by means of little horny spines with which it is provided. It then develops from its hinder end a kind of bladder or cyst filled with fluid (fig. 44, 2), and it constitutes what was formerly called a "cystic worm," under the belief that it was a distinct animal. In this particular case it causes in the pig the disease known as "measles." If now a piece of "measly" pork, containing these little bladder-worms, be eaten by a man, the bladder-worm fixes itself to the mucous membrane of the alimentary canal, throws off its cyst, and becomes at once the "head" of the full-grown tapeworm. It then commences to throw out buds from its hinder end, till ultimately there is produced in *another* individual the same flattened, jointed body with which we originally started.

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[1] A *ganglion* is a little mass or knot of nervous matter, containing nerve-cells, and giving origin to nerve-fibres.

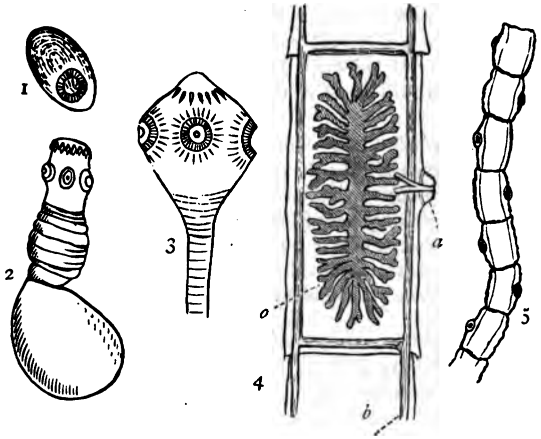


Fig. 44.—1. Egg, containing the young Tape-worm; 2. A bladder-worm, magnified; 3. Head of adult Tape-worm, magnified, showing the hooklets and suckers; 4. A single joint, magnified, to show the branched ovary (*o*) and the water-vascular vessels (*b*); 5. A fragment of *Tænia solium*, showing the generative joints.

Similar phenomena are known in other cases, which cannot be noticed here. It is sufficient to mention that man is not only subject to three species of mature tape-worms, but is also liable to the attacks of the bladder-worm, or immature form of at least one other species of tape-worm peculiar to another animal. Thus the disease known to medical men as "hydatids" is caused by the presence of the young or "cystic" forms of one of the tape-worms of the dog. In England this disease is a rare one; but in some countries, such as Iceland, it is of comparatively common occurrence.

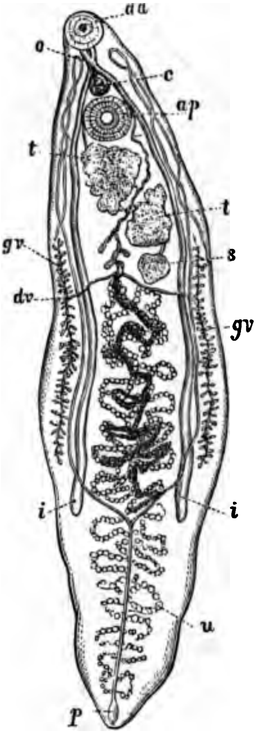


Fig. 45.—A Trematode Worm (*Distoma lanceolatum*), enlarged. *aa* Anterior sucker, with the mouth at its bottom; *ap* Posterior sucker; *o* Gullet, dividing behind into the two branches of the intestine, which are unbranched, and terminate behind in blind extremities (*i i*); *p* External opening of the water-vessels, which divide above so as to cross the blind ends of the intestine. The remaining letters refer to the different parts of the reproductive organs.

ORDER II. TREMATODA.—The Trematode worms or "Flukes" (fig. 45) merely require to be mentioned. They are all internal parasites, and are found inhabiting different situations in various animals, but especially in birds and fishes. They are all more or less flattened and leaf-like in shape, and they adhere by means of one or more suctorial discs. It is from the presence of these discs or pores (Gr. *trema*, a pore) that the name of the order is derived. The alimentary canal is always merely hollowed out of the body, and may be simply divided or greatly branched. It always terminates behind in blind extremities; and the water-vessels open at the hinder end of the body by a special pore. The most important of the *Trematoda* is the common Liver-fluke, which is found in the gall-bladder or ducts of the liver in sheep, and is the cause of the disease known as the "rot." It is ovate in shape, flattened on the two sides, and of a yellow colour. It is occasionally known to occur in man.

ORDER III. TURBELLARIA.—This order includes the so-called *Planarians* and the Ribbon-worms (*Nemertidæ*). They are never parasitic, and their integument is always furnished with cilia; whilst the alimentary canal may be simple or branched, and may or may not have a distinct vent. The *Planarians* (fig. 46) are small jelly-like, soft-bodied, ovate or elliptical creatures, which are commonly found in fresh water, or on the sea-shore, or in moist earth. The *Nemertidans* or Ribbon-worms are commonly found on the sea-shore, and differ from the *Planarians* in their completely worm-like shape.

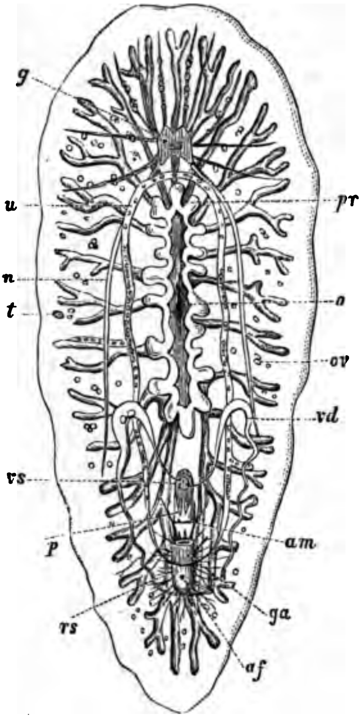


Fig. 46.—One of the Turbellarian Worms (*Leptoplana tremellaris*), enlarged. *o* Mouth; *pr* Proboscis; *g* The principal nerve-ganglion, placed in the anterior part of the body, and giving off numerous radiating branches (*n*). The remaining letters refer to different parts of the reproductive organs.

ORDER IV. ACANTHOCEPHALA (Gr. *akantha*, thorn; *kephale*, head).—The "Thorn-headed worms" included in this order are all internal parasites, but they merely require to be mentioned. They are amongst the most formidable parasites with which we are acquainted, and are found inhabiting the alimentary canal in many birds, fishes, and mammals, but not, as far as is yet known, in man. They owe their name to the fact that the anterior end of the body forms a kind of proboscis or snout, which is armed with recurved hooks.

ORDER V. GORDIACEA.—The "Hair-worms" are also of little importance. They are thread-like parasites which spend the earlier part of their existence in the interior of various insects, which they leave in order to lay their eggs. They are singularly like horse-hairs in appearance, and often attain a length many times greater than that of their insect-host.

ORDER VI. NEMATODA (Gr. *nema*, thread; *eidos*, form).—In this order are the "Round-worms" and "Thread-worms," both of which are internal parasites, together with a number of forms which lead a permanently free existence. They have all a rounded worm-like shape, and possess a distinct mouth, a freely-suspended alimentary canal, and a vent. The most important of the parasitic forms are the common Round-worm (*Ascaris*) and the Thread-worm (*Oxyuris*), both of which inhabit the alimentary canal of the human subject; and the Guinea-worm, which burrows amongst the tissues of man, especially of the legs, and attains a length of several feet. Of the free Nematode worms, the most familiar is the so-called "vinegar-eel" (*Anguillula aceti*).

ORDER VII. ROTIFERA.—The *Rotifera* or "Wheel-animalcules" owe both their scientific and popular name to the fact that the anterior end of the body is almost always furnished with one or two circlets of cilia (fig. 47), which, when in motion, vibrate so rapidly as to produce the illusory impression of a quickly-rotating toothed wheel. They are all microscopic in size, and are mostly to be found inhabiting collections of fresh water. They are generally free-swimming active little creatures, but some of them are permanently fixed. The males and females mostly differ very greatly from one another, the males being much smaller than the females, devoid of the most important of the internal vital organs, and living a merely transitory existence, the sole end of which is to fertilise the eggs of the female.

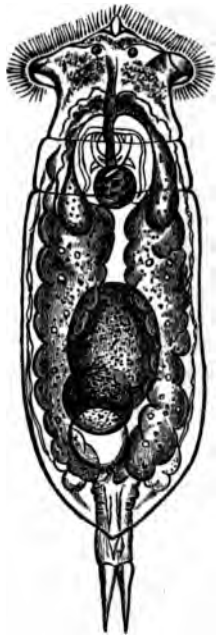


Fig. 47.—Rotifera. *Eosphora aurita*, one of the Wheel-animalcules. Enlarged about 250 diameters. (After Gosse.)

The free-swimming Rotifers, such as *Eosphora* (fig. 47), propel themselves rapidly and gracefully through the water by the vibrations of the cilia which clothe the disc, and which act in the same manner as the propeller of a screw-steamer. The hinder end of the body is also furnished with a little pair of pincers, by which the animal can moor itself at will to aquatic objects. In spite of their microscopic dimensions, the Wheel-animalcules have a quite complicated anatomical structure, possessing a well-developed digestive canal and masticatory apparatus, a nervous system, rudimentary organs of vision, and organs of reproduction.

The Rotifers were long confounded with the Infusorian Animalcules, from the great resemblance in external appearance between the two. The internal organisation of the *Rotifera* is, however, of a much higher grade than that of the *Infusoria*. The Wheel-animalcules may be found in most ponds and streams, and are beautiful objects for microscopic examination, partly owing to their graceful movements, and partly from the transparency of the integument, which enables the observer very readily to see the internal organs. Although aquatic in their habits, the Wheel-animalcules appear to be able to withstand being dried up, and they can be revived by the addition of a little water, even after they have been kept in a dried condition for some months.

CHAPTER VIII.

THE ANARTHROPODA.

WE include under the name of *Anarthropoda* all those Annulose animals to which the name of "Worms" would be ordinarily applied, leaving on one side, however, the wormlike *Scolecids* which have been already treated of. As before said, the Ringed Worms or "Annelides" (*Annelida*) are the most important types of the *Anarthropoda;* and all of them have the body distinctly ringed or divided into successive segments placed one behind the other; while any lateral appendages which may be present are unjointed (Gr. *a*, without; *arthros*, joint; *podes*, feet). There are no proper blood-vessels, and the nervous system has the form of a double, knotted, ventrally-placed chain, the front masses of which are always placed above the gullet, and constitute a kind of *brain*. The division of the *Anarthropoda*, besides the Annelides, comprises the Spoon-worms and their allies (*Gephyrea*), and the singular Arrow-worms (*Sagitta*); but the first of these are alone of sufficient importance to demand special notice here.

CLASS ANNELIDA.—The body in the Ringed worms is composed of a number of rings which are all similar to one another, except at the two ends of the body; hence both the scientific and popular names of the group. The class includes the Leeches, Earth-worms, Tube-worms, and Sand-worms, all of which are more or less worm-like in shape, and all of which (with the exception of the Leeches) have lateral appendages, which, however, are never jointed to the body. The nervous and digestive systems have the same structure as is characteristic of the Annulose sub-kingdom. There is, however, no distinctly developed blood-circulatory system, the blood being believed to be represented by a fluid, with solid particles in it, which fills the body-cavity. There is, however, a peculiar system of vessels, which are contractile, contain a fluid with solid particles, and send branches to the breathing-organs, when these exist. This system is believed to correspond to the water-vascular system of the Echinoderms and Scolecids, and not to the blood-vessels of the higher animals, and it is therefore termed the "pseudohæmal" system (Gr. *pseudos*, falsity; *haima*, blood). Respiration is sometimes effected by the general surface of the body, assisted, probably, by certain peculiar pouches (the so-called "segmental organs"); but in other cases there are distinct gills or *branchiæ*—that is, organs adapted for breathing air dissolved in water.

The class *Annelida* is divided into the four orders of the *Hirudinea* (Leeches), *Oligochæta* (Earth-worms), *Tubicola* (Tube-worms), and *Errantia* (Sand-worms), each of which may be briefly noticed.

ORDER I. HIRUDINEA.—The order *Hirudinea* (Lat. *hirudo*, a horse-leech) comprises only the Leeches, of which some inhabit the sea, whilst others live in fresh water, and a few live in moist places on land. They are characterised by the fact that the body is not provided with lateral appendages of any kind, but is furnished with a sucker or disc at one end only or at both extremities (fig. 48). They swim by means of a serpentine bending of the body, or crawl about by alternately fixing and detaching the suckers, much after the manner of progression in the common "Looper" caterpillars.

The most familiar of the Leeches are the common Horse-leech (*Hæmopsis*) and the Medicinal Leech. The former of these occurs abundantly in this country, but is of no commercial value, as its teeth are blunt. The Medicinal Leech owes its value to the fact that the mouth is furnished with three semicircular toothed jaws (fig. 48, *b*, *c*) which meet in a point, and are sufficiently strong to saw through the skin. It is of rare occurrence in this country, but occurs abundantly in the south and east of Europe, and is largely imported from Hungary, Bohemia, Russia, and France. The Medicinal Leeches inhabit pools and ponds, especially in marshy districts, and are captured in various ways, amongst which one of the commonest is to drive some animal, such as a horse, into the water, and allow these bloodthirsty Annelides to fasten upon it. They give rise to a very extensive branch of commerce, and are so valuable that it has been thought worth while in some places to cultivate and breed them artificially in large marshes always maintained at the same level.

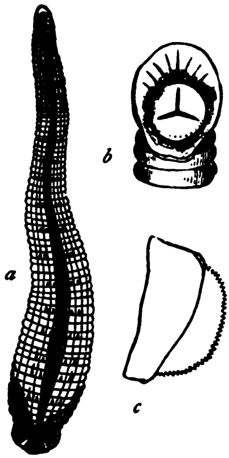


Fig. 48.—*a* Medicinal Leech (*Sanguisuga officinalis*); *b* Anterior extremity of the same, showing the sucker; *c* One of the jaws detached.

ORDER II. OLIGOCHÆTA.—The order *Oligochæta* (Gr. *oligos*, few; and *chaité*, bristle) is well exemplified by the common Earth-worm (*Lumbricus terrestris*). The entire order is characterised by the fact that the body is furnished with rows of bristles, which act as organs of locomotion. The bristles are comparatively few in number, and are not supported upon "foot-tubercles," as in the higher Annelides. There are no distinct breathing-organs, unless the function of respiration is discharged by a number of little sacs ("segmental organs") which are placed on the sides of the body, and open externally by minute apertures.

The common Earth-worm attains a length of a foot or more, and may be composed of over one hundred and twenty rings.

It possesses eight rows of locomotive bristles, but these are so transparent that they can more easily be felt than seen. It is a timid animal, nocturnal in its habits, and spending the daytime in the burrows which it excavates in the soil. It feeds exclusively on vegetable matters, and is perfectly harmless. Beside the Earth-worms, the order *Oligochæta* comprises a number of little Annelides, which may commonly be found in ponds, rivers, and lakes, and which are known as Water-worms and Mud-worms.

ORDER III. TUBICOLA.—The order *Tubicola* (Lat. *tuba*, a tube ; and *colo*, I inhabit) owes its name to the fact that the animals belonging to it have the power of protecting themselves within tubes (fig 49). In some cases the investing tube is composed of carbonate of lime, but in other cases it is constructed of particles of sand or fragments of shell agglutinated together. Unlike the Annelides of the two preceding orders, the *Tubicola* possess special breathing organs in the form of filamentary gills or "branchiæ," in which the fluid of the pseudo-hæmal system is exposed to the action of the outer water. The gills, however, are placed only on or near the head, as it is only this portion of the body which is naturally protruded from the investing tube.

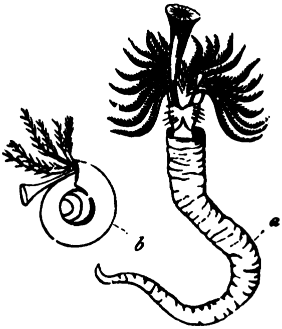


Fig. 49.—*a Serpula contortuplicata*, showing the feathery gills attached to the head; *b Spirorbis communis.*

Amongst the most familiar examples of the *Tubicola* may be mentioned the *Serpulæ* (fig. 49, *a*), the winding and contorted calcareous tubes of which must be known to every visitor at the sea-side. Equally common is the little *Spirorbis* (fig. 49, *b*), in which the tube is coiled up into a flat spiral, and is cemented by one side to the fronds of sea-weed or to some other solid object. Less familiar than the preceding, but still very abundant on many coasts, are the long tubes of the "Shell-binder" (*Terebella conchilega*), composed of particles of sand, pieces of shell, and small pebbles, all cemented together; the cigar-shaped tubes of *Pectinaria*, composed almost wholly of grains of sand or minute stones; and the aggregated sandy tubes of *Sabellaria*. The Tube-worms are exceedingly timid and retiring in their habits; but are rendered objects of the greatest beauty by the gorgeous colours of their gill-plumes.

ORDER IV. ERRANTIA.—The "Errant" Annelides (Lat. *erro*, I wander) are so called because they lead a free existence, and are not confined in tubes. Like the preceding, they breathe by means of gills; and these organs, to suit their mode of life, are placed in tufts along the back or sides of the body. The organs of locomotion consist of lateral unjointed appendages or "foot-tubercles," which carry tufts or bristles. The anterior rings of the body are generally so modified as to form a sort of head, which is provided with eyes and with two or more unjointed feelers.

Amongst the best known of the Errant Annelides is the Lob-worm or Lug-worm (*Arenicola piscatorum*, fig. 50, C), which burrows in the sand of all our coasts, and is largely used by fishermen for bait. The Lob-worm forms a kind of subterranean tunnel in which it lives, and it is one of the authors of the numerous worm-casts which one sees on every sandy shore between tide-marks. It attains a considerable length, and has a large rounded head, which is destitute of eyes. Its colour varies much, and its gills have the form of little scarlet tufts

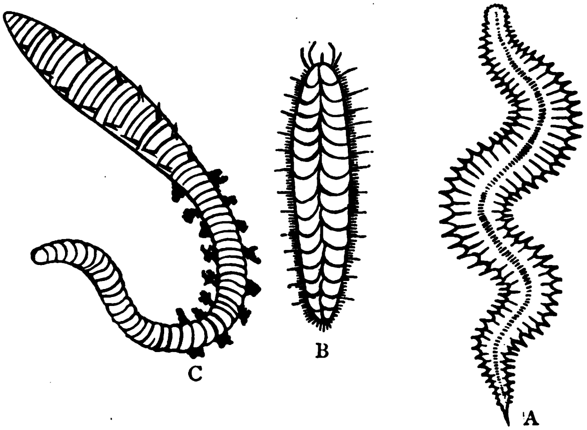


Fig. 50.—A, Hairy-bait (*Nepthys*); B, One of the Sea-mice (*Polynoe*); C, The Lob-worm (*Arenicola piscatorum*).

placed on the sides of the body. The large Sea-mice (*Aphrodite*) would hardly be recognised at first sight as belonging to the group of the Worms, owing to the fact that the back is covered with a felt-like covering of interwoven bristles, which glitter with all the changing colours of the rainbow. It is commonly thrown up on the shore after storms. The beautiful Sea-centipedes (*Nereida*), again, can be found plentifully on our coasts, usually hiding under stones at low water. Many of the members of this group attain a large size, and are adorned with the most brilliant colours, whilst some have the additional attraction of being phosphorescent in the dark.

CHAPTER IX.

ARTHROPODA.

1. GENERAL CHARACTERS OF THE ARTHROPODA.
2. CHARACTERS OF THE CRUSTACEANS.

DIVISION ARTHROPODA OR ARTICULATA.—The members of the sub-kingdom *Annulosa* comprised under this head are generally known as *Articulata* (Lat. *articulus*, a joint) or *Arthropoda* (Gr. *arthros*, a joint; and *pous*, foot), since they are provided with *jointed appendages, articulated to the body*. Besides the above and the characters which they share with all the *Annulosa*, the Articulate animals have one or two other peculiarities which are eminently characteristic of them. Thus the body is composed of a number of distinct rings or segments, arranged longitudinally one behind the other, and often extremely definite in number. It is only in a few forms, also, that the segments present any great resemblance to one another over the greater part of the body; and even in these some of the segments of the anterior end of the body constitute what is at once recognisable as the head. The skin, further, is almost always more or less completely hardened by the deposition in it of a horny substance, often with the addition of lime, so that it forms a strong hollow shell, to the inner surface of which the muscles are attached. There is therefore no necessity for any internal skeleton. Lastly, as a rule, the limbs are also hollow, and have the muscles attached to their interior.

The *Arthropoda* are divided into four great classes—viz., the *Crustacea* (Crabs, Lobsters, &c.), the *Arachnida* (Mites, Spiders, and Scorpions), the *Myriapoda* (Centipedes and Millepedes), and the *Insecta* (or true Insects).

CLASS I. CRUSTACEA.—The great class of the *Crustacea*, comprising Crabs, Lobsters, King-crabs, and numerous other allied forms, is distinguished from the remaining three classes of the *Arthropoda* by the fact that its members are all adapted for a more or less aquatic life, living either in water or in moist places. In accordance with this peculiarity, whenever the Crustaceans have distinct breathing-organs, these are in the form of gills or "branchiæ," adapted for breathing air dissolved in water. Besides this leading character, Crustaceous animals are further distinguished by mostly having more than four pairs of legs, by carrying jointed appendages on the hinder extremity of the body (abdomen), and by having two pairs of jointed feelers or "antennæ."

The class *Crustacea* includes such a large number of animals, of such very varied appearance and structure, that it will be sufficient here to notice shortly some of the more important and characteristic forms.

The Lobster (fig. 51) is a very readily obtainable example, and will illustrate the leading points of interest in the order. If we look at the Lobster, we see at once that it is made up of two parts which we should call familiarly the "head" and the "tail." The so-called "head" is really composed of the segments of the head proper, and of the chest (thorax), and is covered by a great plate or shield, which is termed the "carapace." Behind the carapace comes the "tail," or, as it is scientifically called, the "abdomen," which is composed of a number of rings movably joined together. From the possession ot a long and movable abdomen, the Lobster is placed in a tribe of Crustacea called *Macrura* (Gr. *makros*, long; *oura*, tail). Each segment of the abdomen carries a pair of oar-like appendages, used in swimming, and called "swimmerets," and the last pair is greatly dilated, and forms a powerful swimming-paddle. There are five pairs of legs used in progression, and for this reason the Lobster is placed in an order of the *Crustacea* called *Decapoda* (Gr. *deka*, ten; *pous*, foot). The first three pairs of these legs are furnished at their ends with nipping-claws, of which the hinder two pairs are very small; but the first pair is greatly developed, and constitutes the great claws. On the under surface of the head is the mouth, surrounded by a complicated series of modified appendages used in masticating and cutting the food. The last three pairs of these appendages are so little altered from ordinary limbs, that they are known as foot-jaws. The head also carries the eyes and two pairs of

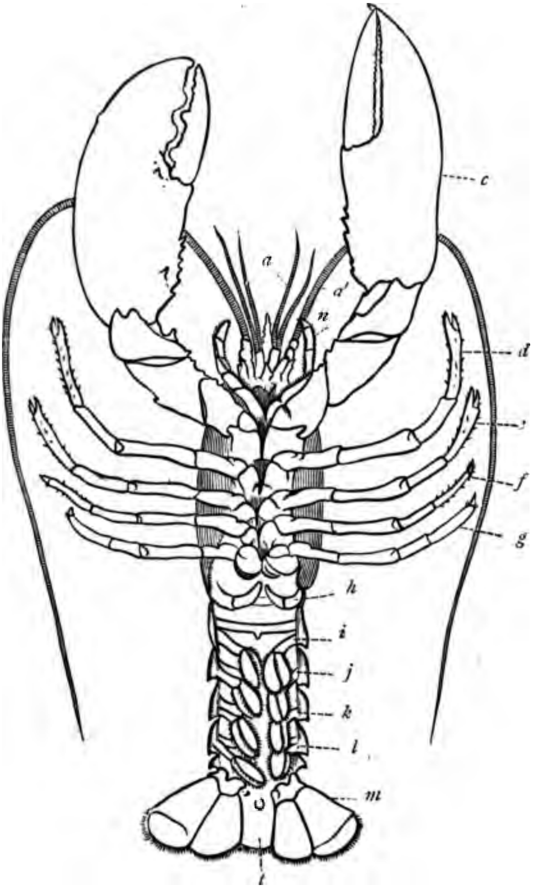


Fig. 51.—The common Lobster (*Homarus vulgaris*), viewed from below. *a* The lesser antennæ; *a'* The greater antennæ; *n* The last pair of foot-jaws; *c* The great claws, or first pair of legs; *d, e, f, g* The last four pairs of walking legs; *h, i, j, k, l, m* The six pairs of abdominal appendages, the last five being "swimmerets," and the last of all being greatly expanded; *t* The last segment of the body, without appendages.

feelers or "antennæ," a small pair (*a*) and a long pair (*a'*). The eyes are supported upon long and movable stalks, and for this reason the Lobster is placed in a division of the *Crustacea* to which the name of *Podophthalmata* is given (Gr. *pous*, foot; and *ophthalmos*, eye).

The digestive system of the Lobster consists of a mouth, gullet, globular stomach, and intestine, terminating in a distinct vent. There is also a well-developed liver. The heart is placed on the back (dorsally), and respiration is carried on by means of a number of pyramidal gills or branchiæ attached to the bases of the legs, and placed in a kind of chamber formed beneath the great shield or carapace on each side of the body. The water which fills the gill-chambers is constantly renewed by the movements of the legs, and thus the gills are kept continually supplied with fresh water.

The Lobsters are exclusively found in the sea; and though they can live a considerable time out of the water, they are essentially aquatic animals. They are exceedingly voracious, and are usually captured by means of "lobster-pots," or baskets baited with some kind of carrion or garbage. When injured, or even if greatly alarmed, they throw off one or both of the great claws; but these appendages soon grow again, though not so large as before. They also cast their shells periodically, since the resisting nature of this covering does not allow of their growth. When fresh they are very brightly coloured; but they turn to a uniform and brilliant red when boiled. They are most ordinarily about a pound in weight, but they sometimes grow to three or four pounds.

Nearly allied to the Lobster, and very similar in essential structure, are the Cray-fish, the Shrimp, the Prawn, and other less familiar forms. Also nearly related to the "Long-tailed Crustaceans" are the Hermit-crabs and their allies. In the Hermits the "tail" or abdomen is still well developed, but it is quite soft, and is not protected by any shell. The animal, therefore, protects this part of the body by appropriating the empty shell of some Mollusc, such as the Periwinkle or Whelk, and he changes his borrowed dwelling whenever it becomes inconveniently small for him.

The remaining group of the "decapodous" or ten-footed Crustaceans is constituted by the Crabs (fig. 52). These are placed in a tribe called *Brachyura* (Gr. *brachus*, short; *oura*, tail), in consequence of the rudimentary condition of the "tail" or abdomen. In fact, not only is the abdomen quite rudimentary, but it is completely tucked away out of sight; so that when the animal is looked at from above, nothing is visible except the great shield or carapace. As in the Lobster and the Hermit-crabs, the eyes of the crabs are supported upon movable stalks, so that these, too, belong to the division of the *Podophthalmata.* Most of the Crabs live between tide-marks, or in shallow water; but the so-called "Land-crabs" live habitually on shore, and sometimes even far inland. The Crabs, in fact, differ very greatly from one another, both as to the exact places that they inhabit, and their mode of life. Most of them have the feet organised for walking, either on dry land, or between tide-marks, or on the bottom of the sea; and though the gait of the common Crabs is awkward enough to look at, some species can run with great swiftness. Some of the Crabs also swim both actively and gracefully. Whole volumes might be written about the wonderful forms assumed by many of the Crabs, and their equally wonderful habits. The common

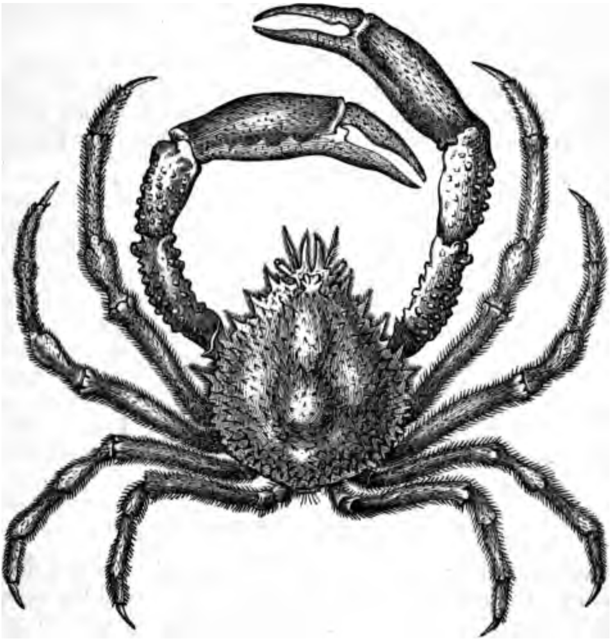


Fig. 52.—The Spiny Spider-crab (*Maia squinado*).

Shore-crabs and Edible crabs live under stones, or in the crevices of the rocks, and can be observed on almost every coast. The crabs, like all other crustaceous animals, undergo periodically the operation of casting their shell and producing a new one, an operation of a very remarkable character from a physiological point of view. They have also the power of reproducing their limbs, if deprived by accident of any of these organs. Finally, it may be mentioned that the young Crabs are very unlike the adults, being furnished with a well-developed abdomen, and thus coming to resemble the permanent condition of the Lobster.

Passing over the Locust-shrimps and their allies, we come to another group of Crustaceans known as *Isopoda* (Gr. *isos*, equal; *podes*, feet). Some of these live on dry land, and a good example is to be found in the common Wood-lice (fig. 53), so well known as occurring in crevices of old walls and under stones. Though terrestrial in their habits, the Wood-lice always affect moist places, and their breathing-organs consist of gills or branchiæ. Other members of this group, such as the Water-slaters and Rock-slaters, live in fresh waters or in the sea. The Isopods differ from the Crustaceans previously mentioned in not having the eyes supported upon movable stalks, and they are therefore placed in a division to which the name of *Edriophthalmata* is applied (Gr. *hedraios*, sitting or sessile; *ophthalmos*, eye). Also belonging to the "Sessile-eyed" Crustaceans are the familiar little "Sand-hoppers" (*Talitrus*) of the sea-shore, and the "Fresh-water Shrimps" (*Gammarus*) of our ponds and streams.

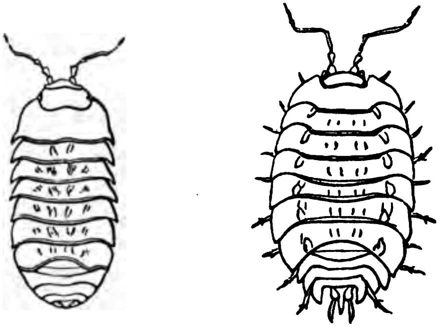


Fig. 53.—Common Wood-lice (*Oniscus*), magnified.

The King-crabs (*Limulus*) represent another order, to which the name of *Xiphosura* (Gr. *xiphos*, a sword; *oura*, tail) is applied, from the fact that the end of the abdomen is furnished with a long sword-like spine (fig. 54). The whole of the upper surface of the body in these Crustaceans is protected by a kind of buckler, and in the centre of the lower surface is the mouth, surrounded by six pairs of appendages, the free ends of which form pincers or nipping-claws, whilst the bases are rough and spiny, and act as jaws. The King-crabs often attain a very large size, and are sometimes known as "Molucca Crabs." They are natives of the sea, and are found on the Atlantic coast of North America, in the West Indies, and in the Indian Ocean. They live in shallow water, and often crawl up on the beach; and the upturned tail-spine is capable of inflicting a severe wound, if incautiously trodden upon. The flesh is occasionally eaten, and fowls are often fed upon the eggs.

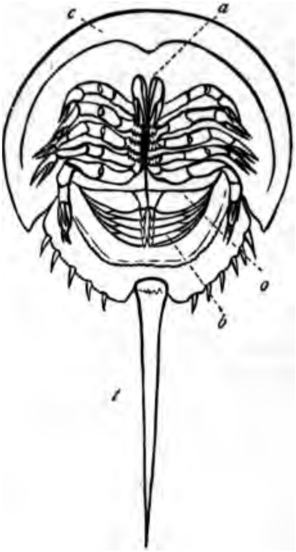


Fig. 54.—King-crab (*Limulus polyphemus*) viewed from below.

Less familiar than any of the preceding are many very minute Crustaceans, belonging to several different orders, but familiarly known as "Water-fleas" (fig. 55). Subjoined is an illustration of some of these diminutive organisms, which swarm in countless myriads in most of our ponds in summer-time. Many also occur in the sea, and some of them are of great geological importance, their minute shells sometimes making up the greater part of even extensive formations.

The last group of the Crustaceans which need be noticed here, is that of the *Cirripedia* (Lat. *cirrus*, a curl; *pes*, foot) comprising the so-called Barnacles and Acorn-shells, both very unlike Crustaceans to look at. They are distinguished by the fact that whilst they are free-swimming little creatures in their young condition, when adult they are immovably fixed by their heads to some solid object. In this fixed condition, as a rule, the internal organs are protected by a calcareous shell, composed of many pieces; and the only parts of the body which remain movable are the legs, which are constantly thrust out of the shell and again drawn in in quest of food.

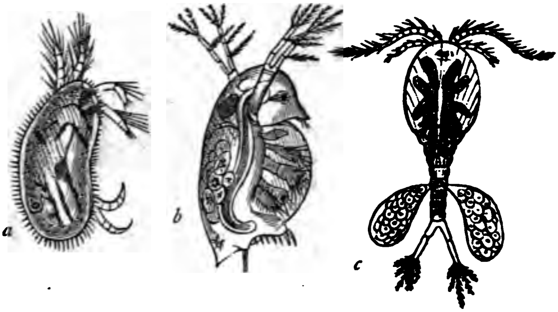
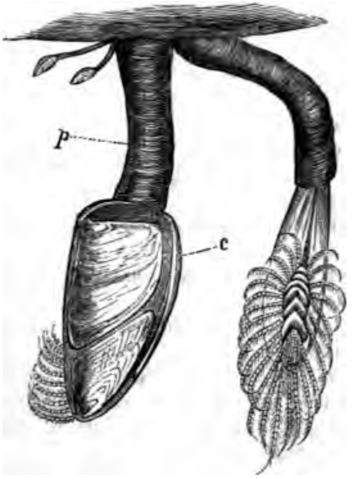


Fig. 55.—Water-fleas. *a Cypris; b Daphnia; c Cyclops.*



g. 56.—Two fully-grown individuals of the common Barnacle (*Lepas anatifera*), growing upon a foreign body. *p* The stalk of attachment; *c* The body of the animal enclosed in a shell, from which the legs can be protruded.

The Acorn-shells (*Balanus*) occur in myriads upon every solid object between tide-marks. In these the head is fixed to the centre of a membranous or shelly plate, and the body is protected by a limpet-shaped shell, composed of several pieces, and having an opening at its summit. This opening is closed by a movable lid, and from it the animal can protrude its legs, which are constantly employed, like a little sweeping-net, in search of food.

In the Barnacles (fig. 56), on the other hand, the anterior end of the body is much lengthened, and forms a kind of stalk by which the animal is attached to some solid object, such as a rock, a floating log of timber, the side of a ship, or even some marine animal.

Owing to a superficial resemblance between the fringed feet of the Barnacles and the webbed foot of a water-bird, the older English historians and naturalists entertained the belief that the Barnacles were actually the young of the " Bernicle-goose," a winter visitant to our shores. Thus Gerard does not hesitate to say that he has positively seen the Barnacle, on coming to maturity, fall into the sea " where it gathereth feathers, and groweth to fowle bigger than a mallard and less than a goose, having blacke legs and bill or beake, and feathers blacke and white."

CHAPTER X.

CLASS II. ARACHNIDA.

THIS class includes the Mites, Ticks, Scorpions, and Spiders, and is, as a whole, very nearly related to the *Crustacea.* The *Arachnidans,* however, are all air-breathers, so that when they have any distinct breathing-organs, they are never in the form of gills, but are always either air-sacs (*pulmonary sacs*) or breathing-tubes (*tracheæ*), or both combined. In none of the *Arachnida,* further, are there ever more than *four pairs of legs; and the rings which compose the tail or " abdomen " never carry any limbs of any kind whatever.* The eyes are always "sessile," that is to say, they are not supported upon stalks; and if antennæ exist, only one pair is present, and these are much modified, and do not act as feelers. Lastly, the head is always amalgamated with the chest (thorax), so as to form a single mass, which is termed the " cephalothorax."

Amongst the lower forms of the *Arachnida* are many small animals, of which the most important are the Sea-spiders and the Mites. The Sea-spiders (fig. 57, *a*) are inhabitants of the sea, and they are very often referred to the *Crustacea.* They are all very long-legged, some of them extraordinarily so, and in many cases the legs contain prolongations from the stomach. They are all grotesque-looking creatures, which may be found at low water upon stones or marine plants, or which are attached parasitically to marine animals.

The Mites (fig. 57, *b, c*) form with the Ticks the order *Acarina,* and are distinguished by the fact that the abdomen is amalgamated with the cephalothorax to form a single mass. The Mites are all minute animals, the habits of which are very various. Some are found upon various plants (fig. 57, *b*); others are parasitic upon water insects when young, but swim about freely in the water when adult; others live permanently as parasites upon other animals, such as insects; and others inhabit decaying organic substances, as is the case with the well-known "Cheese-mite."

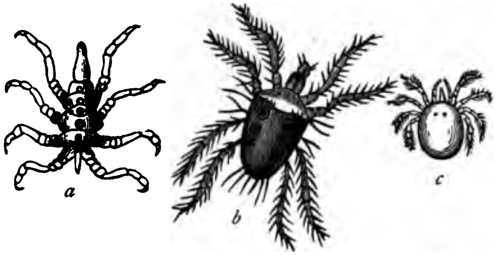


Fig. 57.—*a* Sea-spider (*Pycnogonum*); *b* Sociable mite (*Tetranychus*); *c* Water-mite (*Hydrachna*).

The Ticks are parasitic upon various of the higher animals, such, for example, as the dog and sheep; and they are furnished with a powerful beak, armed wlth hooked spines. By means of this organ, the Ticks not only attach themselves firmly to their unwilling host, but are also enabled to draw forth his blood for their nourishment.

Amongst the largest and most formidable of the *Arachnida* are the Scorpions, which form the order *Pedipalpi.* They are characterised by having a distinctly-segmented abdomen, which passes into the cephalothorax without any well-marked line of boundary (fig. 58). The last joint of the tail or abdomen is hooked, and is perforated by a tube leading down to a poison-gland at its base. It is by means of this that the Scorpions "sting," and the wounds inflicted by the larger species are not only extremely painful, but in some cases are actually dangerous to life. The feelers (antennæ) of the Scorpions constitute small nipping-claws, and two of the appendages of the mouth are developed into great pincers; but these are not capable of inflicting injury on man. The process of respiration is carried on by four pairs of chambers or "pulmonary sacs," which open on the surface, and thus obtain air, by means of distinct apertures placed on the under surface of the abdomen. The

Scorpions live in the warmer parts of the temperate zone and in tropical regions, and are generally found hiding under stones or in the crevices of walls. They are much, and justly, dreaded by the inhabitants of the countries in which they occur. Though capable of using the sting in defence or offence, the Scorpions employ this weapon chiefly in the capture of their prey, consisting mainly of insects. These they hold firmly in their nipping-claws, and then sting to death. In walking, the Scorpions carry the hooked abdomen curved over the back, in such a manner that the point of the sting is directed forwards.

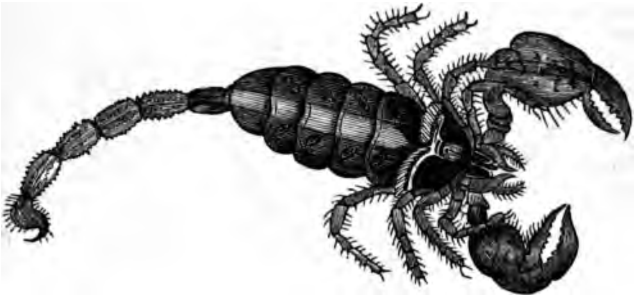


Fig. 58.—Scorpion (reduced).

The last of the *Arachnida* which need be noticed are the true Spiders or *Araneida*. The Spiders are very commonly confounded with the Insects, but they are at once distinguished by having four pairs of legs (fig. 59), by not having the abdomen distinctly ringed, and by having the head and thorax amlgamated into a "cephalothorax." They are distinguished from the Scorpions by having the abdomen distinctly marked off from the thorax, and only joined to it by a narrow stalk. Like the Scorpions, the Spiders breathe by means of "pulmonary sacs;" but, in addition to these, they possess air-tubes or "tracheæ." These are branching tubes which open externally by distinct apertures, and carry air to all parts of the body, their membranous walls being kept from collapsing by a horny filament which is coiled up in their interior.

From their rapacity and their general repulsiveness of appearance, the Spiders are not such popular objects of study as the Insects; but they nevertheless present many points of great interest, which cannot be touched upon here. They are all "carnivorous," living upon other animals, and all of them possess the power of constructing webs, which they employ either in the capture of their prey or in the construction of their own habitations. The material of which the web is made is the secretion of special glands, and it is moulded to its proper shape by being passed through certain conical little organs which are placed at the extremity of the abdomen, and are termed the "spinnerets." The spinnerets are either four or six in number, and each has its apex perforated by a great number of little holes. The silk is at first fluid, and hardens rapidly on being exposed to the air. A single filament of silk is thus produced by each of the perforations in the spinneret, so that what we usually call a single "thread" in a spider's web is really a cable, composed of a great number of the most delicate fibres agglutinated together. Many species do not form regular webs, but they all use the silk to form little cases

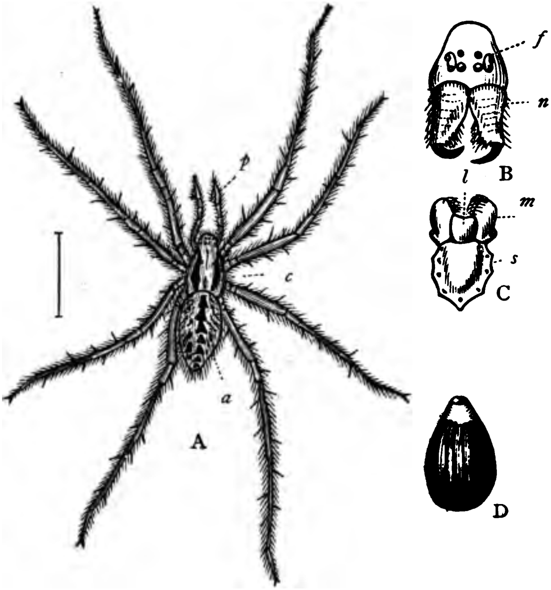


Fig. 59.—A, The male of the common House-spider (*Tegenaria civilis*), considerably magnified; *c* Front portion of the body, consisting of the amalgamated head and thorax; *p* Feelers attached to the jaws; *a* Abdomen. B, Front portion of the head of the same, showing the eight eyes (*f*), and the poison-jaws (*n*). C, Under side of the head and trunk, showing the true jaws (*m*), the lower lip (*l*), and the horny plate to which the legs are attached (*s*). D, Diagram of one of the air-chambers or breathing-organs. (Figs. A, B, and C are after Blackwell.)

or "cocoons" in which the eggs are protected, and which the parent sometimes carries about with her. The young spiders are quite like the old ones in form, though of course smaller; but they change their skins repeatedly before attaining maturity.

The British Spiders are sufficiently harmless, so far as man is concerned; but some of the species of other countries are capable of inflicting a bite which may produce serious or even fatal results. This is effected, not by a sting like that of the Scorpions, but by a pair of strong hooked jaws (fig. 59, B), which have their points perforated for the escape of a poisonous fluid secreted by special glands. All the Spiders use their poison-fangs for killing their prey, consisting usually of insects, which they capture in their webs, or hunt down for themselves. Some of the large tropical spiders, however, attain comparatively gigantic dimensions, and are occasionally known even to capture small birds.

CHAPTER XI.

CLASS III. MYRIAPODA.

The third class of the *Arthropoda* is that of the *Myriapoda* (Gr. *muria*, ten thousand; *pous*, foot), and is a very small one, including only the Centipedes and Millepedes and their allies. They are distinguished from both the preceding classes and from the Insects by the following characters: *The head and chest* (*thorax*) *are distinct from one another, but the thorax and abdomen are not separated by any boundary-line*, the segments of the two being nearly similar (fig. 60). The body almost always consists of more than twenty rings; and *the hinder segments, which correspond to the abdomen, always carry locomotive limbs.*

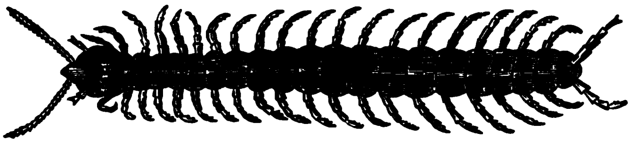


Fig. 60.—Centipede (*Scolopendra*), after Jones.

There is one pair of antennæ, the number of legs is not *definite*, and the breathing-organs are in the form of air-tubes (tracheæ).

The Centipedes (fig. 60) are familiarly known in the person of a very common British species, which is of small size, and, though not attractive in appearance, is perfectly harmless. Some of the tropical forms, however, attain a length of several inches, and are able to inflict a very severe or even dangerous bite. This they effect by means of hooked "foot-jaws," which are perforated for the discharge of a poisonous fluid. The Centipedes, therefore, *bite*, and do not *sting*, as do the Scorpions. They are further characterised by the fact that the number of legs is not indefinitely great (usually from fifteen to twenty pairs), and the feelers or antennæ have not less than fourteen joints each,

The Millepedes (fig. 61) are even more repulsive in appearance than the Centipedes, but they are quite harmless, and live principally upon decaying vegetable matter, whereas the latter are animal feeders. The body is rounded and worm-like, and is supported by an indefinitely great number of minute thread-like legs. The feelers or antennæ, further, are short, and have only six or seven joints each. The British Millepedes are of small size, but a South American species attains a length of several inches.

Fig. 61.—Millepede (*Iulus maximus*), a small example, of the natural size.

CHAPTER XII.

CLASS IV. INSECTA.

The true Insects (Lat. *inseco*, I cut into) are the best known and most popular of Articulate animals, though commonly many other creatures, such as Spiders, Mites, Centipedes, and others, are loosely included under this head. The true *Insecta* are distinguished from the preceding classes of Articulate animals by the fact that *the three divisions of the body—the head, thorax, and abdomen—are always distinct from one another in the adult animal; there are never more than three pairs of legs in the adult, and these are carried by the three rings of the thorax; and the abdomen of the mature insect never carries any locomotive appendages.* Respiration is effected by means of "air-tubes" or "tracheæ," and in most insects two pairs of wings are developed upon the second and third segments of the thorax.

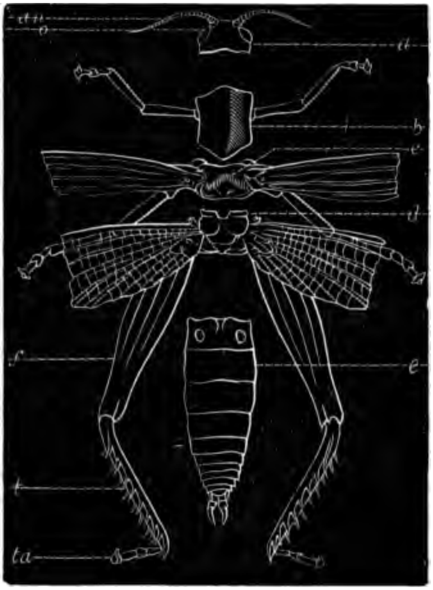


Fig. 62.—Diagram of the external anatomy of an Insect. *a* Head, carrying the eyes and antennæ; *b* First ring of the thorax, carrying the first pair of legs; *c* Second segment of the thorax, carrying the second pair of legs and the first pair of wings; *d* Third segment of the thorax, carrying the third pair of legs and the second pair of wings; *e* Abdomen, without limbs, but carrying appendages concerned in reproduction.

The skin of Insects is more or less hardened by the deposition in it of a horny matter, and the body is deeply cut into segments. The head is always distinctly marked (fig. 62), and carries a pair of jointed feelers or "antennæ," a pair of eyes, and the appendages of the mouth. The antennæ are certainly used as organs of touch, but they appear to be the organs of other higher senses, of which it is not impossible that hearing is one. The eyes are almost always what is called "compound"—that is to say, they are composed of a great number of simple eyes, each perfect in itself, and placed side by side. The organs of the mouth are very complicated, and adapt the Insect for biting hard substances, for sucking up fluids, or for both together. The thorax in insects (fig. 62, *b*, *c*, *d*) consists of three rings, which are more or less completely amalgamated, but are generally pretty easily recognised. In adult Insects each of these rings carries a pair of jointed legs, so that there are three pairs of legs in all. In most insects, also, the two hinder segments of the thorax carry each a pair of wings, in the form of membranous expansions, strengthened by hollow tubes or "nervures." Either of these two pairs of wings, however, may be absent; or both may be absent or rudimentary; or, lastly, the front pair may be hardened so as to be useless in flight, but to form protective cases for the hinder wings. The abdomen of Insects (fig. 62, *e*) is composed of several segments, which are more or less freely movable on one another, but which never carry locomotive limbs, as is so commonly the case with the *Crustacea*. The last segments of the abdomen, however, often carry appendages, which are primarily connected with reproduction, but which are often converted into weapons of offence and defence. Of this nature are the stings of bees and wasps, the forceps of the common Earwig, and the "ovipositors" of Saw-flies and many other Insects.

As regards the internal anatomy of Insects, little need be said here. There is a complete alimentary canal, usually with accessory glands, supposed to represent the salivary glands and kidneys of higher animals. The circulation is carried on mainly by a long contractile tube, placed along the back, and known as the "dorsal vessel." Respiration is effected by means of branched air-tubes or "tracheæ," which commence at the surface by minute apertures, and then proceed inwards, branching as they go, so that every part of the body is richly supplied with air. The nervous system has the regular *Annulose* type, consisting essentially of a chain of little nervous masses or ganglia, united by cords, and placed along the lower or ventral surface of the body.

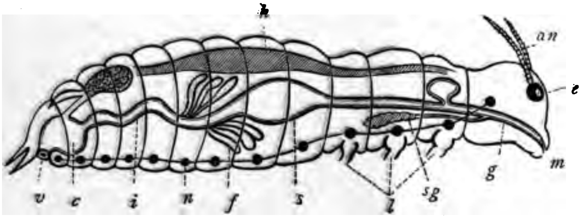


Fig. 63.—Diagram of the anatomy of an Insect. *an* Antennæ; *e* Eye; *m* Mouth; *g* Gullet; *sg* Salivary gland: *s* Stomach; *f* Tubes supposed to represent the liver; *i* Intestine; *c* Chamber into which the intestine opens; *v* Vent; *h* Heart; *n* Nervous system; *l* Bases of the legs.

The sexes in Insects are distinct, and most of them lay eggs (or are "oviparous"). In some of the lower orders of the Insects, the young, on escaping from the egg, resemble the adult in everything except in size, and they undergo no alteration in reaching maturity, except that they grow larger. All the Insects in which this occurs are destitute of wings when fully grown. For this reason they are often called *Aptera* (Gr. *a*, without; *pteron*, a wing). In all other Insects the adult is furnished with wings (with a few unimportant exceptions), and the young passes through a series of changes, known as the "metamorphosis," before maturity. The young Insect, on leaving the egg, is known as the "*larva*" (Lat. *larva*, a mask), and in most cases it constitutes what would popularly be called a "caterpillar" or a "grub." In this state it is not only much smaller than the adult, but is destitute of wings, and is often furnished with organs which are either not present at all in the adult or are quite rudimentary in the latter, and which enable it to lead a life quite different to that of the fully-grown Insect. After several changes of skin, the "larva" passes into the second stage, when it is known as the "pupa" (Lat. *pupa*, a doll). After remaining a longer or shorter time in this second stage, the Insect passes into the third and final stage, that of the perfect Insect, when it is known as the "imago" (Lat. *imago*, an apparition). The "pupa," however, varies considerably in its characters in different Insects, and upon these differences important divisions of Insects have been founded. In some cases (fig. 64) the "pupa" is quite active and locomotive, and differs from the larva only in being bigger and in possessing rudimentary wings. In order to convert it into the adult or "imago," therefore, nothing further is necessary than

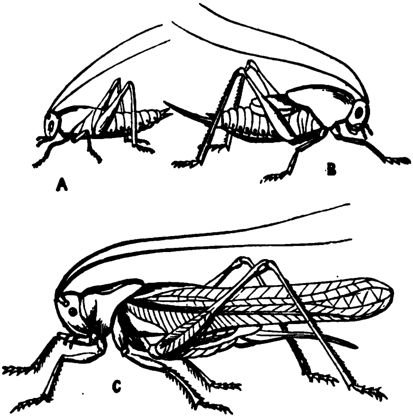


Fig. 64.—Different stages in the metamorphosis of the Grasshopper. A, Larva; B, Pupa, with the rudimentary wings; C, Adult or imago, with the fully-developed wings.

that the pupa should grow, and that its wings should be fully developed. In all Insects in which this occurs — such as Grasshoppers, Dragon-flies, &c. — the metamorphosis is said to be "incomplete." In other cases, however, the "pupa" (fig. 65) differs very much from both the larva and the adult insect or "imago," and the metamorphosis is said to be "complete." The best example of this kind of metamorphosis is to be found in the Butterflies and Moths (*Lepidoptera*). In these Insects the "larva" is worm-like, and constitutes what every one knows as a "caterpillar." It now possesses a horny head, with masticating organs, adapting it for eating solid food, and with little glands, the function of which is to secrete silk. It likewise possesses a variable number of soft, fleshy, temporary feet, which are placed in the hinder part of the body, and which do not correspond with the three pairs of legs proper to the adult, these being present as well. Having remained in this condition for a longer or shorter time, and having cast its skin repeatedly, so as to allow for its rapid growth, the larva passes into the second stage and becomes a "pupa." It constitutes now what is called the "chrysalis," and is quite quiescent, unless irritated, being usually buried in the ground or attached to some foreign object, and being therefore incapable of changing its place. The body is completely covered by a thin horny covering, and in some cases this is still further protected by the dried skin of the larva; whilst in other cases the larva, immediately before entering the pupa-stage, spins for itself a case of silken threads, which surrounds the chrysalis, and is known as the "cocoon." Ultimately, the horny envelope of the chrysalis splits, and gives exit to the perfect winged insect or "imago."

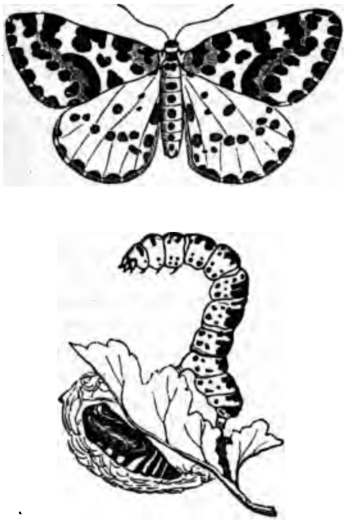


Fig. 65. — Metamorphosis of the Magpie-moth (*Phalæna grossulariata*).

The class *Insecta* is divided into twelve orders, of which only the more important ones require to be noticed here. The wingless or "Apterous" Insects comprise three orders, represented respectively by the disgusting parasites known as Lice, the nearly allied Bird-lice, and the common "Spring-tails," which may be found anywhere under stones or in any damp and dark situation. None of these three orders are of any great importance or interest.

The first order of the Winged Insects is that of the *Hemiptera* (Gr. *hemi*, half; *pteron*, wing), so called because some of its members have the front pair of wings hardened at their bases by horny matter (fig. 67); in others, however, all the wings are simply membranous (fig. 66), and in almost all the two proper pairs of wings are present. The mouth in all the Hemiptera is adapted for suction, and they live upon the juices of plants or animals. As examples of the order may be taken the Field-bug (*Pentatoma*), the Boat-fly (*Notonecta*), the Cochineal insects (*Coccus*), and the Plant-lice (*Aphis*, fig. 66). The Cochineal insects are of considerable importance, as the dried and powdered bodies of the female constitute the substance known as Cochineal, from which is obtained the brilliant pigment carmine. The male insect is winged, and is smaller than the female, which is destitute of wings. They live upon different species of Cactus (*Opuntia*), and are mainly imported from Mexico, Algeria, and the Canary Islands.

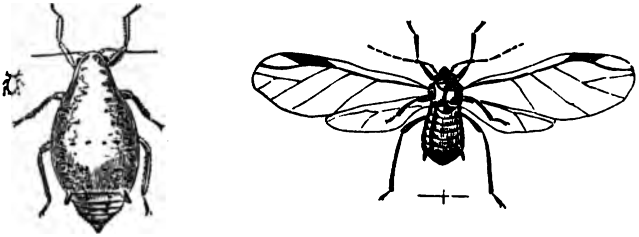


Fig 66.—Hemiptera. Bean Aphis (*Aphis fabæ*), winged male and wingless female.

Numerous species of *Aphides* or Plant-lice are known, and they are amongst the greatest pests of the gardener and farmer, as they are extraordinarily prolific, and live upon the juices of plants. One of the most curious points about the Plant-lice is, that they secrete a sweet sticky fluid, which is expelled from the body by two little tubular filaments placed near the end of the abdomen. Ants are excessively fond of this fluid, and hunt after the *Aphides* in all directions in order to obtain it; and it is a well-established fact that the Plant-lice are actually pleased with this, and voluntarily yield up the coveted fluid to the importunity of the ants.

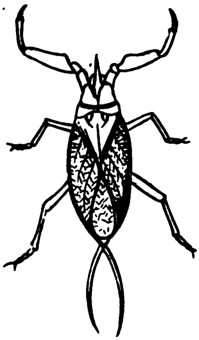


Fig. 67.—The Water-scorpion (*Nepa cinerea*), showing the front wings with their membranous tips and horny bases.

The Wood-bugs and Field-bugs (*Pentatoma*) are commonly to be found in summer on various plants and shrubs, on the juices of which they live. Many of the species are brightly coloured, and most of them emit an acrid and more or less disagreeable odour when handled.

The Boat-flies (*Notonecta*) are to be found in abundance in most ponds. The body is boat-shaped, and they swim about actively, back downwards, by the strokes of the long oar-like hind-legs, which strike the water just like a pair of sculls. The Boat-flies are exceedingly rapacious insects, and they can bite quite severely by means of a strong pointed beak, placed on the under side of the head.

As additional examples of the *Hemiptera* may be mentioned the true Bugs (*Cimex*), the Water-spiders (*Hydrometra*), the Water-scorpions (*Nepa*, fig. 67), the Cicadas, the Lantern-flies (*Fulgora*), and the Frog-hoppers (*Cercopis*).

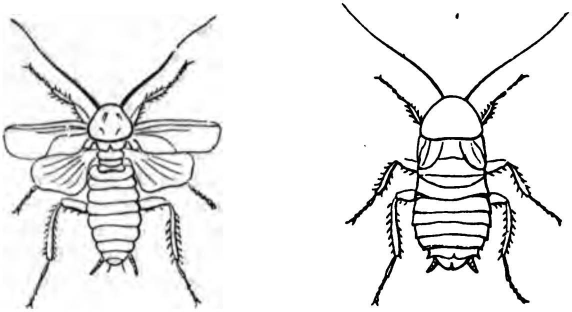


Fig. 68.—Orthoptera. The Common Cockroach (*Blatta orientalis*), male and female.

The next order of Insects is that of the *Orthoptera* (Gr. *orthos*, straight; *pteron*, wing), in which all the four wings are present (fig. 68); but the front wings are generally smaller than the hinder wings, and are of a different texture. The hinder wings are membranous, and are folded lengthways like a fan ; the front wings are leathery, and constitute cases for the posterior wings. This order includes the Crickets (*Achetina*), the Grasshoppers (*Gryllina*,) the Locusts (*Locustina*), the Cockroaches (*Blattina*, fig. 68), and others. The most important of the *Orthoptera*, from a human point of view, are the Locusts, the ravages of which in hot countries must be familiar to every one. The most destructive species is the Migratory Locust (*Acrydium migratorium*, fig. 69), which is very abundant in Africa, India, and throughout the whole of the East. Owing to the rapidity with which they devour everything that they can possibly eat, and owing to their enormous numbers, the Locusts are compelled to be constantly on the move, looking for "fresh fields and pastures new;" otherwise they would starve. It is from these migrations in vast bodies in search of food that the Migratory Locust takes its name. When one of these destructive hosts visits a district, they only need a few hours to convert the most fertile country into a howling wilderness. In an incredibly short space of time every green thing on their line of march is destroyed—every leaf is stripped from every tree, every blade of grass and corn is eaten down, and it is not until the ground is utterly bare that the locusts take wing and seek out some fresh region to devastate.

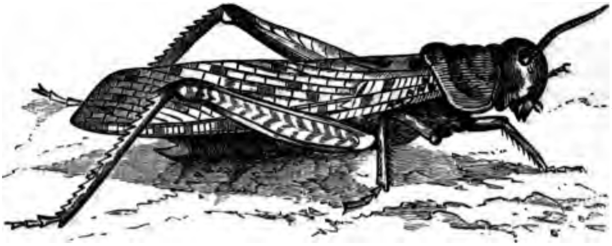


Fig. 69.—The Migratory Locust (*Acrydium migratorium*).

The Grasshoppers (fig. 64) are very like the true Locusts in appearance, but are smaller, and have longer and more slender antennæ. The British species are not sufficiently numerous to be injurious to man; but in other countries, as in North America, the Grasshoppers often abound to a much greater extent, and often do very serious damage to the growing crops. The Crickets, exemplified by the common House-cricket (*Acheta domestica*), are very like the Grasshoppers, again, but have the wings placed flat upon the back, instead of being arranged when at rest in a roof-like manner. The House-crickets chiefly affect the abodes of man, especially in winter; but the Field-crickets and Mole-crickets live in the open country. The Cockroaches, with their flattened bodies and unpleasant odour, are not only far from attractive, but from their voracious habits are very destructive. They are strictly nocturnal in their habits, and appear to be able to eat almost anything. The Earwigs (*Forficula*) are distinguished partly by the peculiar and beautiful structure of the hinder pair of wings, and partly by the possession of a pair of pincers at the extremity of the abdomen. In spite of the foolish popular superstition to which they owe their common name, and their somewhat repulsive appearance, the Earwigs are really quite harmless, feeding upon vegetable substances, and doing no injury to any one except the gardener.

Amongst the remaining more remarkable *Orthoptera* may be mentioned the singular insects which are known as *Walking Sticks* (*Phasmidæ*) and *Walking Leaves* (*Phylliidæ*). The former of these present the most remarkable resemblance to dried twigs, and the latter have an equally close similarity in appearance to leaves. Some of the smaller kinds of this group are found in Europe; but the greater number are inhabitants of warm countries, such as South America, India, Africa, and Australia.

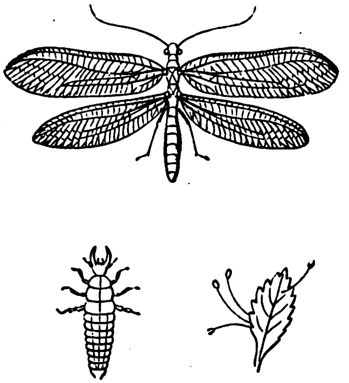


Fig. 70.—Neuroptera. Aphis-lion, imago, larva, and eggs.

The next order of Insects is that of the *Neuroptera* (Gr. *neuron*, a nerve; *pteron*, a wing), in which all the four wings are generally present, and are always membranous, being traversed by numerous delicate nervures, which interlace so as to form a delicate network (fig. 70). The mouth is adapted for mastication—that is to say, for chewing hard substances. As examples of the order may be taken the Dragon-flies (*Libellulidæ*, fig. 72), the Caddis-flies (*Phryganeidæ*), the May-flies (*Ephemeridæ*), the Aphis-lion *(fig. 70), and the* White ants or Termites.

The Termites (fig. 71) are social insects, living in organised communities, and exhibiting many curious phenomena. Some are found in the warmer parts of Europe, but they are mostly inhabitants of hot countries, such as Africa or South America, where they cause great damage by destroying woodwork of all descriptions. The Termites build mounds of different shapes and sizes, sometimes several feet in height, and mostly composed of earth worked up by the saliva of the insects into a material as hard as stone. Each colony of Termites consists of a king and queen and an enormous number of "neuters," or individuals of no fully-developed sex. The king and the queen (fig. 71, A) both originally possessed wings, but they lose these as soon as they found a colony. They are both much larger than the neuters, the queen immensely so, owing to her being distended with eggs (fig. 71, D), and they are kept closely guarded in a chamber in the centre of the nest. The "neuters" are really sexless individuals, and are divided into two sets or "castes," both destitute of wings, and known respectively as the "workers" and the "soldiers." The "workers" perform

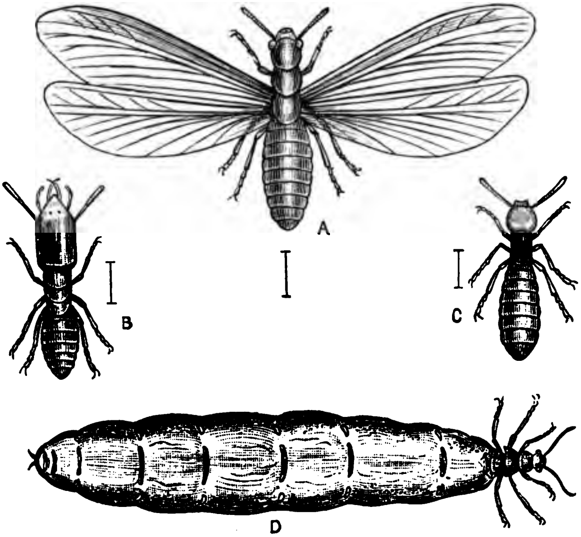


Fig. 71.—Different individuals of the colony of one of the Termites. A, The queen, before the wings are shed ; D, The queen, after the wings are thrown off, and the abdomen has become greatly distended with eggs ; C, Worker ; B, Soldier.

all the ordinary domestic duties of the colony—such as procuring food, nursing the young, and constructing the nest. The "soldiers" have comparatively enormous jaws, and it is their duty to defend the nest against all enemies.

The Dragon-flies (fig. 72) are readily distinguished amongst the *Neuroptera* by their large gauzy wings, their brilliant coloration, their prominent globe-like eyes, and the elegance and rapidity of their movements. The young live in water, the pupa being active, and differing from the larva in possessing rudimentary wings. In all stages of their existence these insects are exceedingly voracious in their habits. The May-flies (*Ephemeridæ*), like the preceding, pass their young stages in water. When adult, they are distinguished by the small size

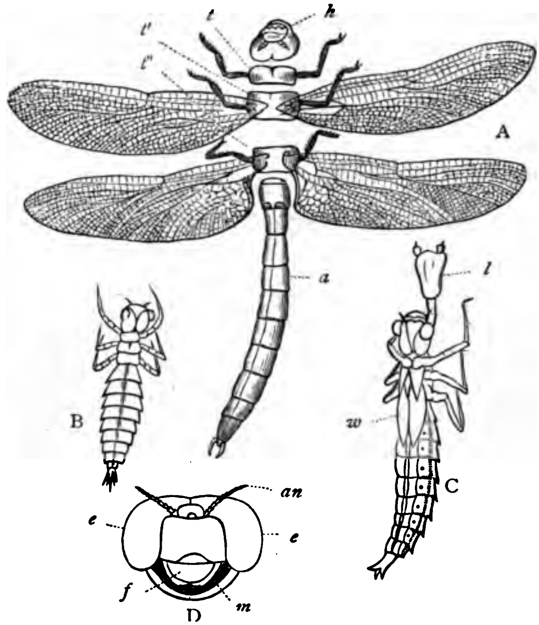


Fig. 72.—A, One of the Dragon-flies (*Æshna grandis*), slightly dissected: *h* Head, carrying the eyes, antennæ, and organs of the mouth; *t*, *t'*, *t''* First, second, and third segments of the thorax slightly separated from one another, each carrying a pair of legs, and the two last carrying each a pair of wings; *a* Tail or abdomen. B, Young form, or "larva," of the same. C, Second stage, or "pupa." D, Head of a Dragon-fly (*Libellula depressa*), showing the feelers or antennæ (*an*), the eyes (*e e*), the hinder pair of jaws (*m*), and the upper lip (*f*)

of the hinder wings and the possession of three long filaments at the extremity of the abdomen. In their perfect condition, the organs of the mouth are rudimentary, and the insect does not take food. Hence its existence in its last and final stage is a very short one, rarely lasting over twenty-four hours. From this fact the technical name of the group is derived, as well as the common name of "Day-flies" sometimes given to them. The Caddis-flies (*Phryganeidæ*) possess four wings, of which the front pair is covered with hairs. The young live in water, and the larvæ protect themselves against their enemies by enclosing their soft worm-like bodies in a case formed of little bits of stick or straw, small pebbles, or minute shells, united together by silken filaments. In this stage they are known as Caddis-worms, and are often used by anglers as bait. In their second or pupal stage, the insect is quiescent, and closes up the open ends of its case by means of a silken lattice. The Aphis-lions (*Hemerobiidæ*) are beautiful insects, with large lace-like wings and prominent eyes. They derive their common name from the fact that the larvæ feed upon the little Plant-lice or *Aphides*. Several species are found in Britain.

Passing over the unimportant order of the *Aphaniptera*, including only the Fleas, we come next to the order *Diptera* (Gr. *dis*, twice; *pteron*, wing). In this order, only the front pair of wings is present (fig. 73), and the posterior wings are rudimentary, and are represented by two clubbed filaments called "balancers." The mouth is adapted for suction. As examples of the Dipterous insects may be taken the House-flies and Flesh-flies (*Muscidæ*), the Gnats (*Culicidæ*), the Forest-flies (*Hippoboscidæ*), and the Gad-flies (*Tabanidæ*).

The true Gnats (fig. 73) and Mosquitoes (*Culicidæ*) belong to a group of the Two-winged Flies, in which the antennæ are comparatively long. They are furnished with a long and slender proboscis, enclosing six lancets or pointed bristles, with which they pierce the skin of animals, and imbibe their juices. The bite of the common Gnat is not very formidable; but the Mosquitoes are amongst the greatest pests of the countries where they are found. The young stages (fig. 73, B and C) of the Gnat's life are passed in water. The Crane-flies (*Tipulidæ*) differ from the Gnats in the shortness of the proboscis, and they owe the common name of "Daddy-Long-legs" applied to them to the great length and slenderness of the limbs. The larvæ are mostly worm-like, and live in the earth. The Forest-flies (*Hippoboscidæ*) and Gad-flies (*Tabanidæ*) are chiefly noticeable for the annoyance which they inflict upon cattle, horses, and other domesticated animals by their bites. The common House-flies, Flesh-flies, and Blue-bottles (*Muscidæ*) are distinguished by their short antennæ, and by the form of their proboscis. The larvæ are worm-like grubs, and for the most part feed upon decaying animal substances, whilst the habits of the adults are extremely varied.

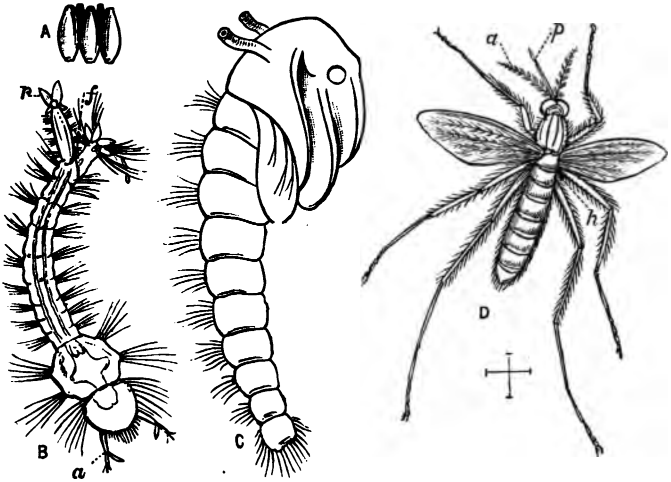


Fig 73.—The common Gnat (*Culex pipiens*). A, A few of the eggs, attached together to form a raft, which floats on the water; B, The larva, suspended in the water head downwards, and showing the antennæ (*a*), the terminal respiratory tube (*r*), and the fins attached to the extremity of the body (*f*); C, The pupa, with the two respiratory tubes attached to the thorax; D, The adult insect, with the well-developed front wings, the rudimentary hind wings or "balancers" (*h*), the antennæ (*a*), and the proboscis (*p*). All the figures are greatly enlarged.

More attractive in every respect than any of the preceding is the great order *Lepidoptera* (Gr. *lepis*, a scale; *pteron*, a wing), comprising the Butterflies and Moths. The name of the order is derived from the fact that the wings—all four of which are usually present—are generally covered with modified hairs or scales, to which the wings owe their beautiful colours. The mouth is purely suctorial in the adult, and is provided with a spiral trunk fitted for drinking up the juices of flowers. The mouth of the "larva," however, is adapted for masticating or chewing hard substances, such as the leaves of trees. The larvæ (fig. 74, *a*) are known as "caterpillars," and are completely worm-like; whilst the pupa is always quiescent, and is known as the "chrysalis." The *Lepidoptera* are roughly divided into the two great groups of the Butterflies or Diurnal *Lepidoptera*, which are active in the day-time, and the Moths or Nocturnal *Lepidoptera*, which come out in the twilight or at night. Some of the Moths, however, are active in broad daylight and in the brightest sunshine.

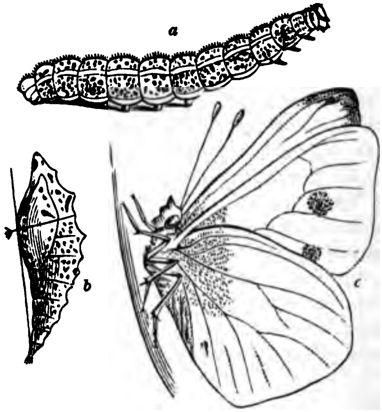


Fig. 74. — Lepidoptera. Large White Cabbage Butterfly (*Pontia brassicæ*): *a* Larva or caterpillar; *b* Pupa or chrysalis; *c* Imago or perfect insect.

The true Butterflies (fig. 74) are distinguished by the fact that the antennæ are clubbed at the ends, whilst the wings are carried in an erect position when the insect is at rest. In the Moths (fig. 75), on the other hand, the antennæ are usually feathery or bristle-like, not clubbed at their extremities, and the wings are not carried erected above the back during repose. In both groups the larvæ or "caterpillars" are worm-like in form, and possess not only the three pairs of legs proper to the adult, but also a variable number of "false legs" in the form of fleshy protuberances developed upon some of the abdominal rings. The lower lip of the caterpillar is also furnished with a spinning organ or

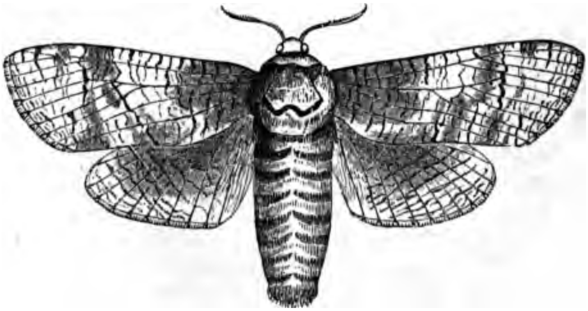


Fig. 75.—The Goat-moth (*Cossus ligniperda*).

"spinneret," by means of which the animal spins silken threads to form its habitation, or a silken case ("cocoon") in which to pass its pupa-stage. The pupa or "chrysalis" is entirely enclosed in a horny sheath, is motionless, and does not eat. In the Moths the chrysalis is more or less rounded, but it is distinctly angular in the Butterflies. When maturity is attained, the outer sheath of the chrysalis splits, and the perfect insect, with its wings, makes its appearance. The wings, however, are at first soft and crumpled, and do not become expanded and fit for flight for some hours.

Apart from the destruction committed by the caterpillars of some of the *Lepidoptera*, the only members of the order which are of importance to man are the various species of *Bombyx*, from which *silk* is derived. Several species are cultivated for this purpose, but by far the most valuable is the common Silk-moth (*Bombyx mori*), which owes its name to the fact that the caterpillar feeds upon the leaves of the common mulberry (*Morus nigra*). It is hardly necessary to say that raw silk is derived from the "cocoon" or silken case in which the caterpillar enwraps itself before becoming a chrysalis. Most of the raw silk imported into Britain is derived from France, Italy, China, and the East Indies.

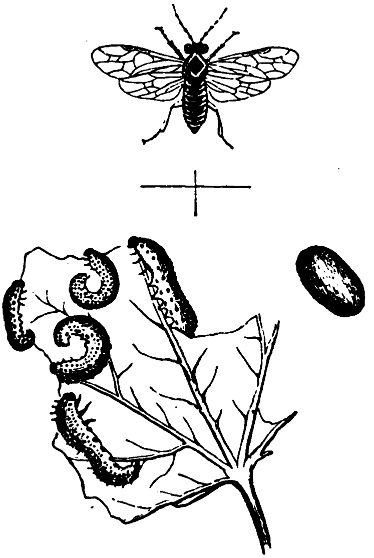


Fig. 76. — Hymenoptera. Gooseberry Saw-fly (*Tenthredo grossulariæ*), larva, pupa, and imago.

The next order of Insects is the large and important one of the *Hymenoptera* (Gr. *humen*, a membrane; *pteron*, a wing), characterised by having four wings, which are all membranous in texture and have few nervures (figs. 76 and 77). The mouth is always furnished with biting jaws, but is often adapted for suction as well. The abdomen of the females is generally furnished with an instrument connected with the process of laying eggs ("ovipositor"), and this often is modified to form a "sting." As examples of the order may be taken the Bees (*Apidæ*), the Wasps (*Vespidæ*), the Ants (*Formicidæ*), and the Saw-flies (*Tenthredinidæ*, figs. 76 and 77, *e*).

The Bees and Wasps are well known as forming social communities, though solitary members of both are not unknown. In both groups these organised communities consist of a vast number of undeveloped females or "neuters"—the so-called "workers"—presided over by a fertile female or "queen." The males are only produced at certain seasons, and they constitute the so-called "drones" of a hive of Bees. The workers discharge all the ordinary duties necessary for the preservation of the colony, such as procuring food, building the nest, and feeding the young. As there is only one set or "caste" of neuters, the duty of defending the nest falls to the lot of all the workers, and is not delegated to a special class of soldiers. The queen is the founder of the colony, and her sole function is to lay eggs. The drones, or males, do no work, and they either die or are killed by the workers so soon as the female is fertilised. Amongst the Wasps, however, both the queens and the drones discharge certain of the active duties connected with the life of the community. In all essential respects the communities of the Bumble Bees (*Bombidæ*) resemble those of the social Bees and Wasps, though each of these has its own habits and peculiarities.

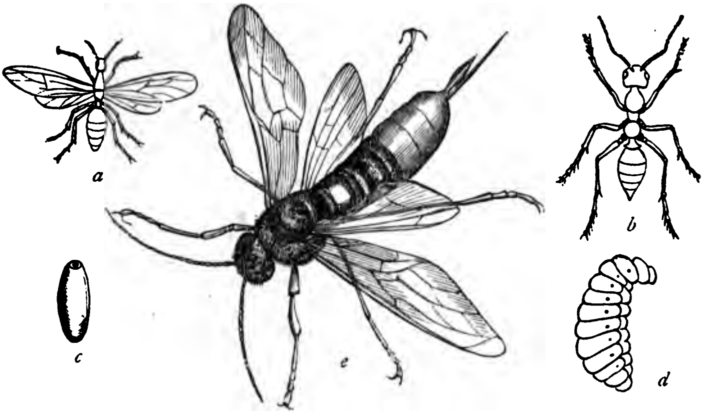


Fig. 77.—*a* Winged male of Ant; *b* Wingless worker of Ant; *c* Pupa of Ant; *d* Larva of Ant, enlarged; *e* The Great Saw-fly (*Sirex gigas*).

The Ants (fig. 77, *a*, *d*) likewise form communities, consisting of males, females, and neuters. The males and females, like those of the very different "White Ants" or Termites, are winged (fig. 77, *a*), and are produced in great numbers at particular times of the year. They then quit the nest and pair, after which the fecundated females lose their wings and form fresh societies. The neuters (fig. 77, *b*) are sometimes all of one kind, but they are sometimes divided into two or even three distinct classes or "castes." The Ants exhibit many most extraordinary and interesting instincts and habits, of which their custom of milking the little Plant-lice (*Aphides*) has been already mentioned. Another very singular habit of some Ants may be just alluded to—their habit, namely, of capturing the pupæ of other species of Ants and bringing them up as slaves. The relations, however, between the masters and slaves vary a good deal in different cases. In the case, for instance, of the Russet Ant (*Formica rufescens*), the masters are so entirely dependent upon their slaves, that they cannot even feed themselves without the help of the latter, and the only work which they perform unassisted is the capturing of fresh slaves. In the Blood-red Ant (*Formica sanguinea*), on the other hand, the slaves are much fewer in number, and the masters are much less dependent upon their good offices. In all cases, the slaves exhibit the greatest devotion to their masters, and are invariably taken the greatest care of by their captors.

Passing over the small group of the *Strepsiptera*, comprising only some small parasites upon Bees and allied insects, we come to the last division of Insects, the Beetles or *Coleoptera* (Gr. *koleos*, a sheath; and *pteron*, wing). The leading peculiarity of the Beetles is that the front wings are hardened

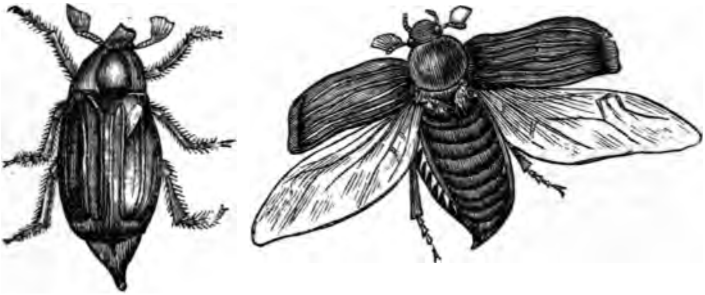


Fig. 78.—Coleoptera. The common Cockchafer (*Melolontha vulgaris*).

by the deposition in them of horny matter, so as to form protective cases, or sheaths, for the hinder wings (fig. 78). The anterior wings are therefore useless as organs of flight, and it is only the posterior membranous wings which are employed in flight. The mouth in all the Beetles is furnished with chewing and biting jaws, and is adapted for dividing solid substances.

The young ("larvæ") of the Beetles are mostly soft fleshy grubs, with a horny head, distinct jaws, six true legs as a rule, and often false legs as well. They live in all sorts of places, and feed on all kinds of vegetable and animal substances. The pupæ are quite quiescent, and do not take food.

The Beetles are, as a general rule, remarkable for their hard polished integument, their glittering, often metallic, colours, and their voracious habits. Many of them do enormous injury to various cultivated plants, either in their larval condition or as perfect insects, or sometimes in both stages of their life. Of the enormous number of known Beetles, the only one which can be said to be of any decided use to man is the so-called "Blister Beetle" or "Spanish Fly" (*Cantharis vesicatoria*). This handsome insect is a native of southern Europe, especially of Italy, Spain, and France, and lives upon the leaves of the ash, lilac, elder, and poplar. It is largely collected and exported for medicinal purposes, as it yields one of the most generally used and efficient of blisters.

SUB-KINGDOM V.—MOLLUSCA.

CHAPTER XIII.

THE *Mollusca* (Lat. *mollis*, soft) owe their scientific name to the fact that they have usually a soft body, but this is mostly protected by a hard external skeleton or "shell," and hence the popular name of "Shell-fish" applied to the animals of this sub-kingdom. All the *Mollusca* are furnished with a distinct alimentary canal, which is always completely shut off from the general cavity of the body (fig. 79). Sometimes there is no distinct organ of the circulation, but when there is, it is placed on the dorsal aspect of the body. The nervous system of the *Mollusca* is wholly different in its arrangement from that of the *Annulose* animals, and in the lower forms it consists of only a single ganglionic mass, giving off filaments in various directions. In the higher *Mollusca* the nervous system (fig. 79, *c c*) consists of three principal ganglia, distributed in a characteristically scattered manner, and united to one another by cords, or massed around the gullet. The most important of these ganglia is the "pedal" ganglion, so called because it supplies nerves to the great locomotive organ of most Molluscs, the "foot" (fig. 79, *f*). There may be no distinct breathing-organs, but as a rule these are present, either in the form of gills or "branchiæ," or as air-chambers adapted for breathing air directly. All the higher Molluscs are simple animals, and perpetuate their kind solely by means of ova; but many of the lower forms have the power of throwing out buds and of producing colonies, much as we have formerly seen in the Hydroid Zoophytes.

In accordance with the nature of the nervous and circulatory systems, the *Mollusca* are divided into two great sections, known respectively as the *Molluscoida* and *Mollusca Proper*. In the *Molluscoida* there is either no circulatory organ or an imperfect heart, and the nervous system consists of a single ganglion or of a principal pair of ganglia. In this division are included the Sea-mosses and Sea-mats (*Polyzoa*), the Sea-squirts (*Tunicata*), and the Lamp-shells and their allies (*Brachiopoda*). In the *Mollusca Proper*, on the other hand, the nervous system consists of three principal pairs of ganglia, and there is a well-developed heart, consisting of at least two chambers. Under this head are included the Bivalve shell-fish, such as Oysters, Cockles, and the like (*Lamellibranchiata*); the Univalve shell-fish, as Whelks, Periwinkles, Slugs, and the like (*Gasteropoda*); certain minute free-swimming Molluscs (*Pteropoda*); and the Cuttle-fishes and Nautilus (*Cephalopoda*). All these groups require to be briefly considered.

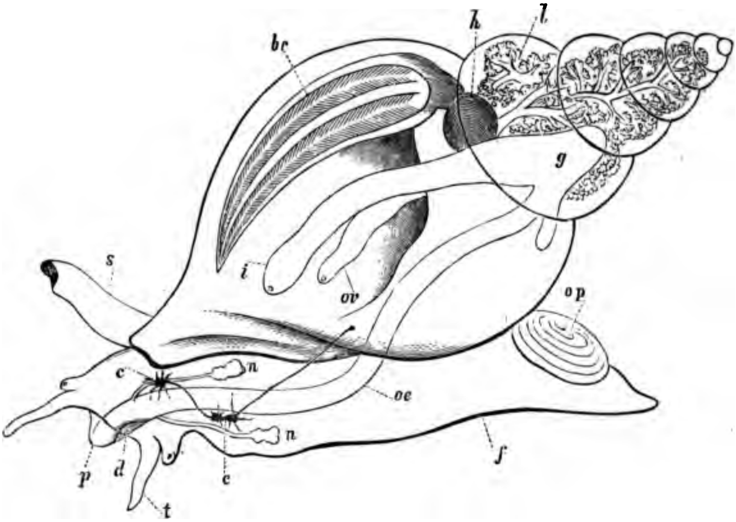


Fig. 79.—Diagram of the structure of a typical Mollusc (the Common Whelk). *f* The muscular "foot": *op* The operculum; *t* One of the tentacles, or feelers, with an eye at its base; *p* The proboscis, retracted, with the mouth at its extremity; *oe* Gullet; *g* Stomach; *i* Intestine, terminating in the anus; *n n* Salivary glands; *l* The liver and the ovary; *h* The heart; *bc* The gill, contained in a hood of the mantle; *s* Breathing-tube, or siphon; *c* and *c* The main nerve ganglia.

CHAPTER XIV.

MOLLUSCOIDA.

Class I. Polyzoa.—The *Polyzoa* (Gr. *polus*, many; *zoa*, animals) are the lowest of the *Mollusca*, and would not be generally recognised as Shell-fish at all. They are popularly known as "Sea-mosses" and "Sea-mats," and are almost universally regarded as sea-weeds by visitors at the sea-side. They are invariably compound — that is to say, they form associated growths or colonies, each consisting of a number of distinct and semi-independent beings, produced by budding from a single primitive organism. The different members of the community are called "polypides," the term "polypite" being only used in connection with the *Hydrozoa*, and the term "polype" being similarly restricted to the *Actinozoa*. The colonies of the *Polyzoa* are very generally protected by a horny

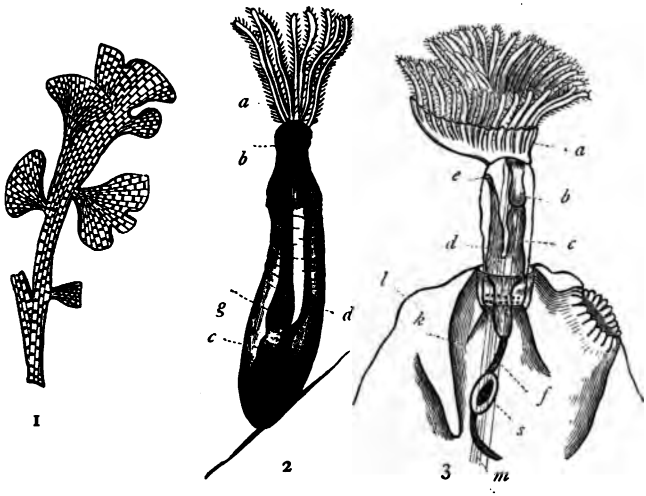


Fig. 80.—Polyzoa: 1. Fragment of one of the Sea-mats (*Flustra*), natural size; 2. A single polypide of *Valkeria*, magnified, showing the circular crown of tentacles; 3. A polypide of *Lophopus*, magnified, showing the horse-shoe-shaped crown of tentacles.

or calcareous covering, and they are in many cases so like the Hydroid Zoophytes as to have been long described as such. The polypides, however, of the *Polyzoa*, are much more highly organised than those of the *Hydrozoa*, since they possess a nervous system, a distinct alimentary canal entirely shut off from the general cavity of the body, and distinct internal reproductive organs.

With very few exceptions, the colonies of the *Polyzoa* are all rooted to some solid object, and, as an example, we may take the Sea-mat (*Flustra*, fig. 81). If such a colony be examined, it is found to consist of an assemblage of little cells or chambers, composed of a horny or calcareous substance, and not communicating one with the other. Each cell contains a minute zoöid, the essential structure of which is much higher than is the case in the *Hydrozoa*. Each polypide (fig. 82) possesses a distinct alimentary canal, with a mouth and vent placed at the mouth or aperture of the cell. The mouth is surrounded by a

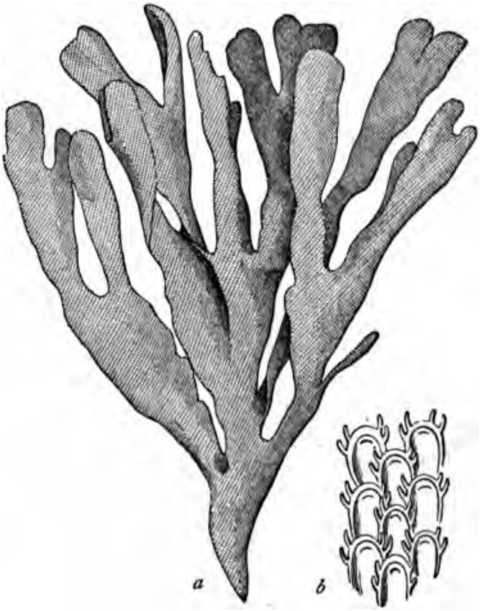


Fig. 81.—*Flustra foliacea*, one of the Sea-mats.

beautiful crown of delicate ciliated tentacles, which are sometimes arranged in a circle (fig. 80, 2), sometimes in a horseshoe or crescent (fig. 80, 3). These tentacles serve both to procure food and as breathing-organs, for there are no gills. On one side of the gullet is placed a single nervous ganglion, and the cell likewise contains the reproductive organs proper to both sexes; but there is no heart. The whole cavity of the cell, however, is filled with a fluid containing solid particles, and corresponding to the blood.

The *Polyzoa* are most commonly and most abundantly found in the sea; but many very beautiful forms are natives of fresh water, and may be found in the ponds, lakes, and streams of our own country.

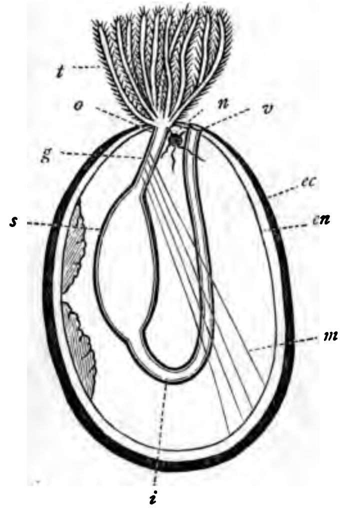


Fig. 82.—Diagram of the animal contained in one of the cells of *Flustra foliacea*. *ec* Outer horny wall of the cell; *en* Inner membranous wall enclosing the internal organs; *o* Mouth, surrounded by tentacles (*t*); *g* Gullet; *s* Stomach; *i* Intestine; *v* Vent; *n* Nervous system; *m* Muscle by which the animal can pull itself into its cell.

Class II. Tunicata.—This class includes a group of animals not at all familiarly known, and mostly of small size. They are often called *Ascidians* (Gr. *askos*, a wine-skin), from the resemblance which many of them exhibit in shape to a two-necked jar or bottle (fig. 83). Their scientific name of *Tunicata* is derived from the fact that the body is enclosed in a leathery integument, which forms a kind of "tunic," and takes the place of the shell of the higher Molluscs. It is remarkable for the fact that it contains a substance which appears to be nearly if not quite identical with "cellulose," the starchy body which forms wood and the woody parts of plants. The two orifices in the outer leathery case or "test" of the *Tunicata* lead into the interior of the animal, and are used for the admission and expulsion of sea-water; and by their means the animal both breathes and obtains food. The opening by which water is admitted is generally regarded as the mouth (fig. 83, *a*), and it leads into a great chamber called the "respiratory sac" (*p*). This sac has its walls perforated like a sieve with numerous ciliated apertures, which lead into a second chamber (*c*) situated at the other extremity of the alimentary canal, and communicating with the outer world by the second opening in the test (*b*). A constant current of water sets in at the mouth, through the respiratory sac, and out again at the second opening of the test. In this way food is obtained, and the animal respires, for the walls of the respiratory sac are richly furnished with blood-vessels. From the bottom of the respiratory sac proceeds the alimentary canal (*g*), to terminate by a distinct vent at the bottom of the chamber into which the second aperture of the test opens. On one side of the mouth is a single nervous ganglion. There is also a distinct heart, but this is a simple tube, open at both ends, and driving the blood periodically first in one direction and then in the opposite.

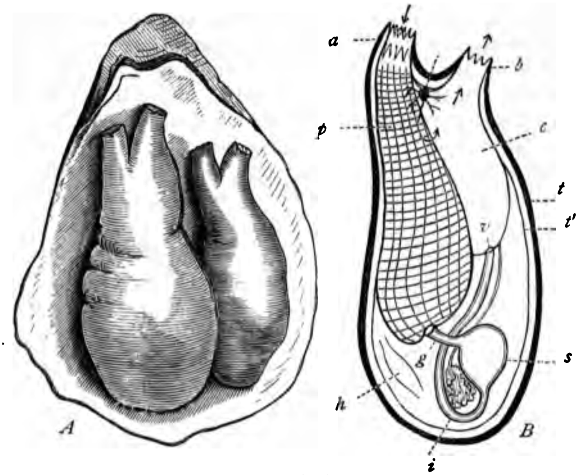


Fig. 83 —*A*, A "simple" Ascidian,—two individuals attached to the inner surface of an Oyster-shell, natural size. *B*, Diagrammatic section of the same: *a* Opening by which the water enters; *b* Opening by which the water escapes: *p* Respiratory chamber; *g* Gullet; *s* Stomach; *i* Intestine; *v* Vent; *c* Chamber into which the water escapes after passing through the respiratory sac; *h* Heart; *t* Outer layer of the integument; *t'* Inner muscular layer or "tunic."

The Tunicaries owe their name of "Sea-Squirts" to the power which they possess of forcibly ejecting a stream of water from the orifices of the test when touched or otherwise irritated.

This power they owe to the presence of a muscular tunic lining the leathery outer case or "test." All the *Tunicata* are marine, and the smaller ones are commonly found sticking to stones or shells at low water or in shallow seas. Some of the tropical forms are found floating in the open ocean far from land, and some are very beautifully phosphorescent at night. Many of them are brightly coloured, and some are exquisitely transparent; but they cannot be said in a general way to present anything specially attractive to the non-scientific observer. The typical Tunicates (such as *Ascidia*, fig. 83) are simple organisms; others are simple and free in one generation, and are attached in long chains in the second generation, becoming free again in the third; whilst others again are united by the close union of their integuments into little crusts or masses, comprising a great number of semi-independent individuals,

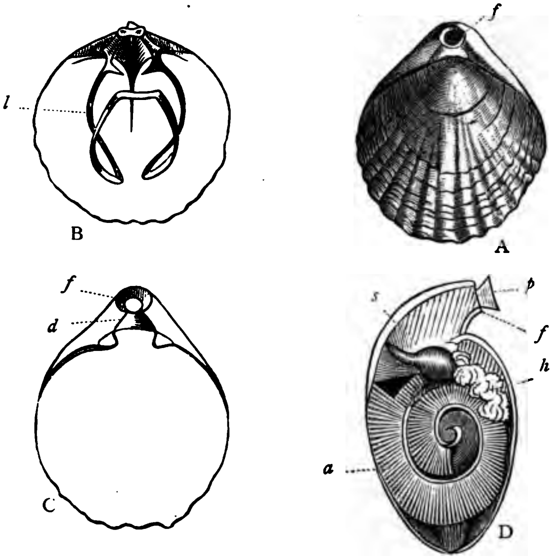


Fig. 84.—*Terebratula* (*Waldheimia*) *flavescens*. A, The shell viewed from behind, showing the smaller valve, and the perforated summit of the larger valve above it. B, Inner view of the smaller valve, showing the shelly loop (*l*) which supports the spiral arms. C, Inner view of the larger valve, showing the foramen or aperture (*f*) in the beak, through which the muscular stalk of attachment passes. D, Longitudinal and vertical section of the animal, showing the spiral arms (*a*), the stomach (*s*), and the liver (*h*). At *f* is the opening in the beak, with the stalk of attachment (*p*) passing through it. After Davidson and Owen. Some details have been omitted in figs. B, C, and D, for the sake of clearness.

and usually attached by one surface to a stone, shell, or seaweed.

Class III. Brachiopoda.—This class includes the so-called Lamp-shells and their allies, and is much more largely represented by fossil forms than by living species. The Lamp-shells are so called because of the resemblance in shape of one valve of the shell (in some cases) to an antique lamp. The name of *Brachiopoda*, however, is derived from the fact that the mouth (fig. 84, D) is furnished with two long spirally-coiled "arms," which carry numerous minute lateral processes or "cirri" (Gr. *brachion*, arm; *pous*, foot). In many instances these arms are supported by a kind of shelly framework, and in all cases they serve to obtain food for the animal. The internal anatomy of the *Brachiopoda* presents many points of relationship to that of the *Polyzoa* and *Tunicata*, especially the former; but the Brachiopods are distinguished by the above-mentioned "arms," and by the fact that the body is always enclosed in a calcareous shell. This shell is always *bivalve*—that is to say, it consists of two pieces or "valves," which are placed respectively on the front and back of the animal. The ventral valve is usually the largest, and generally has its apex or "beak" pierced by an aperture for the transmission of a muscular stalk, by which the shell is moored to some solid object. In some cases, however, as in *Lingula*, the stalk of attachment simply passes between the valves, and sometimes the shell is merely attached by the substance of one valve. All the *Brachiopoda* are natives of the sea; and though very few species are known to exist at the present day, they have a very wide distribution over the world.

CHAPTER XV.

MOLLUSCA PROPER.

The division of the *Mollusca Proper* includes the following four classes:—

1. *Lamellibranchiata*, without a distinct head.
2. *Gasteropoda*, } with a distinct head and a masticatory apparatus or "odontophore."
3. *Pteropoda*,
4. *Cephalopoda*,

CLASS I. LAMELLIBRANCHIATA.—These are well known as *Bivalve Shell-fish*, such as Oysters, Mussels, Scallops, &c.; and they are all either marine or inhabitants of fresh water. They are distinguished from the other shell-fish by having no distinct head, and by having the body more or less completely protected by a "double" or bivalve shell, composed of two pieces or "valves," which cover respectively the left and right sides of the animal. The body is more or less completely enclosed in an expansion of the integument which constitutes what is called the "mantle," and it is by the mantle that the shell is secreted. The mantle, therefore, is, like the shell, composed of two halves; but the halves of the mantle are often united to one another to a great extent, and the mantle-lobes are often prolonged at one point into two long respiratory tubes by which water is conducted to the breathing-organs (fig. 85. *s s*). However completely the halves or "lobes" of the mantle may be united to one another, there is always an opening for the protrusion of the "foot," when this is present, besides the opening by which water is admitted to the gills. The "foot" is sometimes absent, or very small, but it is usually a tongue-like or hatchet-shaped muscular organ (fig. 85, *f*), which

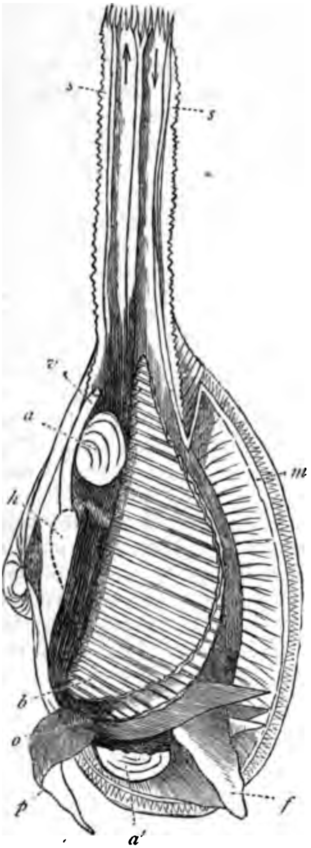


Fig. 85.—Anatomy of a bivalve Mollusc. *Mya arenaria* (after Woodward). The eft valve and mantle-lobe and half the espiratory tubes are removed. *s s* Respiratory tubes; *a a'* Muscles by which the shell is closed; *b* Gills; *h* Heart; *o* Mouth; *f* Foot; *m* Cut edge of the mantle.

may perform very different functions. Usually it enables the animal to make short leaps, or to bury itself in the sand; but in other cases (as in the common mussel) it is connected with a gland which secretes the tuft of silky threads by which these shells are temporarily or permanently moored to solid objects.

As the shell of the bivalves consists of two pieces, special means are necessary for its opening and closure. The closure of the shell is effected by means of one or two muscular bands (fig. 85, *a a'*), by which the valves are pulled together. The shell is opened simply by relaxing these muscles, when the valves spring apart in consequence of the elastic force of a band of horny fibres situated between the points or "beaks" of the valves. In most cases, also, besides the "ligament" just mentioned, the valves are united to one another at the beaks by means of interlocking projections or "teeth."

The breathing-organs of the bivalves are in the form of two or four leaf-like gills (fig. 85, *b*), hence their name of *Lamellibranchiata* (Lat. *lamella*, a thin plate; Gr. *bragchia*, gill). When the lobes of the mantle are not united to one another, the water is admited to the gills simply by opening the valves of the shell. When the opposite is the case, the water is admitted by one aperture and let out again by another. Very often, especially in those bivalves which live buried in sand or mud, the margins of these openings are prolonged into longer or shorter tubes, which may be separate or may be united on one side (fig. 85, *s s*). The mouth is furnished with membranous processes, and has no teeth. The particles of food are conveyed to the mouth by the currents of water which are conducted to the gills, and which are driven along by the innumerable vibrating filaments or cilia covering these organs. There is always a distinct heart, of two or three chambers, and the blood is colourless, or nearly so. The nervous system consists of the three principal pairs of ganglia proper to the higher Molluscs.

In looking at the dead shell of any Bivalve, various interesting points as to the anatomy of the animal which inhabited it can usually be made out. Each half or valve of the shell is a much-flattened cone, with the apex, or "beak," placed more or less on one side. As a rule, the beaks point to the shorter side of the shell, and indicate the side on which the head of the animal was situated. On the inside of the shell we observe one, or more commonly two, distinct marks (fig. 86, *a* and *a'*), which are termed the "muscular impressions." Some shells, like the Oysters and Scallops, have only one of these impressions, whilst others have two. They indicate the points where the muscle or muscles closing the shell ("adductor muscles") were attached, and by examining these marks we can tell whether the animal had one or two of these muscles. There is also a mark or groove running round the margin of the shell (fig. 86, *p*), which indicates the line where the mantle was attached to the shell, and this line has sometimes a curious bend in it towards the hinder end of the shell (fig. 86, *s*). When we see this bend or "sinus," we know that the animal possessed long breathing-tubes, which it could draw within the shell by special muscles.

The habits of the *Lamellibranchiata* are very various. Some, such as the Scallops, habitually lie on one side, the lower valve being the deepest. Others are fixed to the bottom of the sea by the substance of one of the valves. Others, such as the Mussel, moor themselves to solid objects by a tuft of silky fibres. Very many live buried in the sand of the sea-shore or the mud of estuaries. Others bore holes in stone or wood, in which they live. Finally, many are permanently free and locomotive.

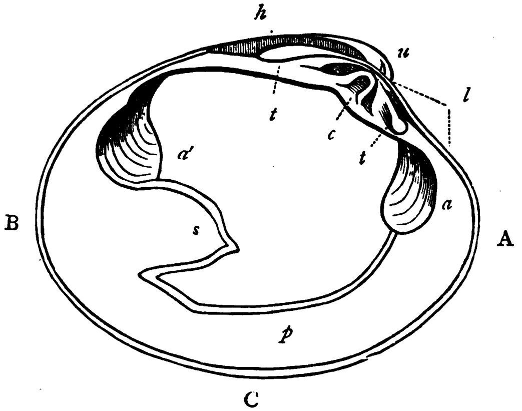


Fig. 86.—Left valve of *Cytherea chione* (after Woodward). A, Anterior margin; B, Posterior margin; C, Ventral margin or base; *u* Umbo; *h* Ligament; *c* Cardinal tooth; *t t* Lateral teeth; *a* Anterior adductor; *a'* Posterior adductor; *p* Pallial line; *s* Pallial sinus caused by the retractor muscles of the siphons.

Many of the Bivalves are of more or less use to man. Thus, the Oysters, Cockles, Mussels, Scallops, Razor-shells, and Clams, afford a more or less palatable and nutritious food. The Pearl-oysters yield the "mother-of-pearl" of commerce, and the true or "oriental" pearls; whilst the fresh-water Mussels of our own country yield an inferior kind of pearl. It may be mentioned in this connection that the "mother-of-pearl" is the inner lining of the shell, and owes its beautiful play of colours to its mechanical structure; whilst the pearls are loose concretions of the same pearly material deposited in concentric layers within the body of the animal round any foreign substance, such as a grain of sand, which may happen to get inside the shell and irritate its inhabitant.

CLASS II. GASTEROPODA.—The Molluscs of this class—such as Snails, Whelks, Limpets, Slugs, and Sea-lemons—differ from the Bivalves in having a very distinct head, in having a curious apparatus of teeth, and in never having a bivalve shell. From the very common occurrence of a shell composed of a single piece, the *Gasteropoda* are often spoken of in a general way as *Univalves* (fig. 87). Many, however, have only a very small shell completely concealed from view (fig. 92); others have no shell at all; and a few have a shell composed of several pieces ("multivalve"). Most of the *Gasteropoda* are further distinguished by the great development of the foot (fig. 79, *f*), which forms a broad flattened disc, on which they creep about, as may be seen in the common Slugs. From this circumstance the name *Gasteropoda* is derived (Gr. *gaster*, belly; *pous*, foot). Some, however, have the foot much modified, and adapted for swimming (fig. 91). In many, also, the hinder part of the foot carries a horny or shelly plate, called the "operculum" (fig. 87, *o*), which serves to close the shell when the animal is withdrawn within it.

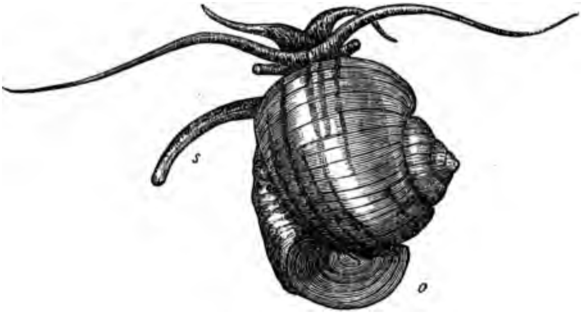


Fig. 87.—*Ampullaria canaliculata*, one of the Apple-shells. *o* Operculum; *s* Respiratory siphon.

As before said, the head of the Gasteropods (fig. 87) is very well marked, and carries two feelers and two eyes, which are often placed on stalks. The mouth is furnished with a curious apparatus of teeth, constituting what is known as the "tongue"

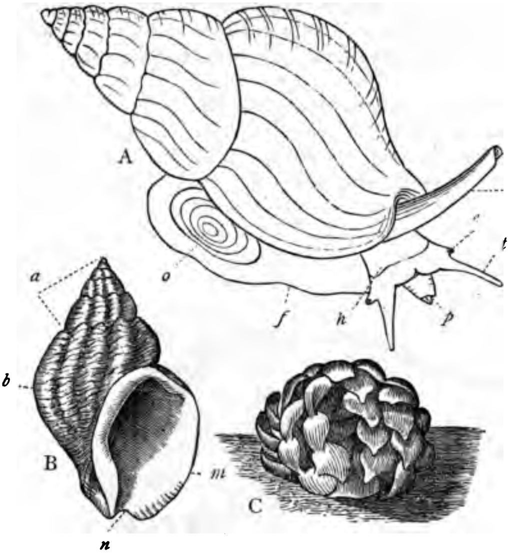


Fig. 88.—A, Sketch of a Whelk (*Buccinum undatum*) in motion : *f* Foot ; *h* Head carrying the feelers (*t*) with the eyes (*e*) at their bases ; *p* Proboscis ; *s* Respiratory siphon, or tube by which water is admitted to the gills ; *o* Operculum. B, Shell of the Whelk ; *a* Spire ; *b* Body-whorl ; *n* Notch in the front margin of the mouth of the shell ; *m* Outer lip of the mouth of the shell. This figure is half the natural size. C, A small cluster of the egg-capsules of the Whelk. (B and C are after Woodward.)

or "odontophore" (fig. 89). It consists of a number of minute pointed teeth carried upon a sort of strap, which works backwards and forwards on a cushion, and acts like a chain-saw.

In most of the ordinary Gasteropods the breathing-organs are in the form of distinct gills or branchiæ, placed in a more or less complete chamber, formed by a folding of the mantle. In many of these the water gains access to the gills by a respiratory tube which is protected in a notch or tubular prolongation of the mouth of the shell, as may be seen in the common Whelk. In other cases, however, there is no such respiratory tube, and the mouth of the shell is therefore not notched, but is simply rounded, as may be seen in the Periwinkle. It has also been observed that those Gasteropods which have the mouth of the shell notched are mostly animal feeders; whilst those in which the mouth of the shell is simply rounded, live upon vegetable matters.

As far as the ordinary water-breathing Gasteropods are concerned, it only remains to add a few words about the shell. The shell may be *multivalve*, or composed of several pieces, but in the great majority of cases it is *univalve*, or composed of but a single piece. It is essentially a hollow cone, with the apex placed a little on one side. In the simplest forms, as in the Limpets, this conical form is permanently retained. In most cases, however, the cone is greatly elongated, and forms a tube which is variously coiled up. In the most typical forms the coils or "whorls" of the shell are wound obliquely round a central pillar, increasing gradually in size to the mouth (fig. 88, B). In some cases, however, the whorls form a flat spiral, and in others the last whorl completely conceals those which preceded it.

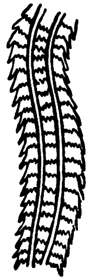


Fig. 89.—Portion of the tongue or odontophore of the common Whelk (after Woodward).

Three groups of the *Gasteropoda* still require a brief consideration. The first of these is represented by the Sea-lemons (fig. 90) and the Sea-slugs, specimens of which may be at any time found creeping about on sea-weeds or attached to the under surface of stones at low water. When fully grown, these slug-like Molluscs are wholly destitute of a shell, but they have a small shell when young. When they possess any distinct respiratory organs, these are in the form of gills, which are not protected in a chamber of the mantle, but are placed without any defence on the back or sides of the body. Hence the scientific name of *Nudibranchiata* (Lat. *nudus*, naked; Gr. *bragchia*, gill) applied to this group.

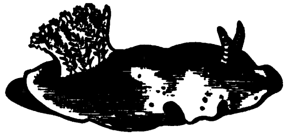


Fig. 90.—*Doris Johnstoni*, one of the Sea-lemons.

The second group is that of the *Heteropoda* (Gr. *heteros*, diverse; *pous*, foot), comprising a number of curious forms which are found swimming about at the surface of the open ocean, instead of creeping about at the bottom of the sea. In order to adapt them for this mode of life, the foot is so modified as to form a compressed fin, instead of being a creeping disc.

Carinaria (fig. 91) may be taken as a good example of the group. It has only a very small limpet-shaped shell protecting the gills; but some of the Heteropods have a large shell, capable of protecting the entire body of the animal; while others, again, are entirely destitute of a shell. *Carinaria* is found, swimming back downwards, in the Mediterranean and other warm seas, and is so transparent that the course of the intestine can be seen along its whole length.

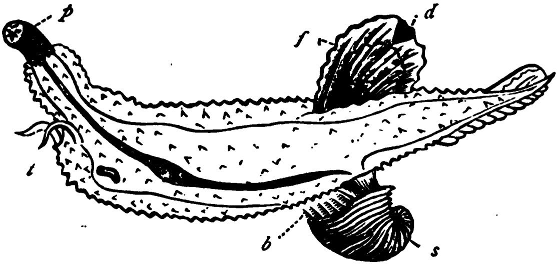


Fig. 91.—*Carinaria* (after Woodward). *p* Proboscis and mouth; *t* Tentacles; *b* Gills; *s* Shell; *f* Foot.

The last group of the class is that of the "air-breathing" Gasteropods, so well known as Land-snails, Pond-snails, and Slugs (fig. 92). All the members of this group are formed to breathe air directly, instead of through the medium of water, and they therefore never possess gills or branchiæ. In place of these, they have a pulmonary chamber or lung, formed by a folding of the mantle, and having air admitted to it by a round hole on the right side of the neck, which can be opened or shut at will. Though thus adapted for breathing air directly, many of the members of this group can only live in damp and moist places, whilst others habitually live in fresh water. Our common Pond-snails are good examples of these last. The condition of the shell varies very much. Some, such as the common

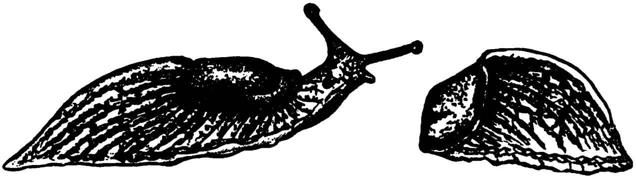


Fig. 92.—*Limax Sowerbyi*, one of the Slugs (after Woodward).

Land-snails, have a well-developed shell within which the animals can completely withdraw themselves for protection. Others, such as the common Slugs (fig. 92), have a rudimentary shell which is completely concealed within the mantle. Others are entirely destitute of a shell. They all agree with the typical Gasteropods in creeping about upon a broad flattened foot.

CLASS III. PTEROPODA.—The Molluscs included in this class are all very minute in point of size, and they are all "oceanic" —that is to say, they are found swimming near the surface of the open ocean, far from land, and often in enormous numbers. They are distinguished by having two wing-like fins (figs. 93 and 94) attached to the sides of the head, and formed by a modification of a portion of the foot. As a rule, the body is protected by a delicate symmetrical glassy shell, but some have the body completely naked. The Pteropods are found in all seas, from the tropics to within the arctic circle; and they sometimes occur in such numbers as to discolour the water of the ocean for many miles. They constitute one of the chief articles of food of the whale, and are in turn themselves carnivorous.

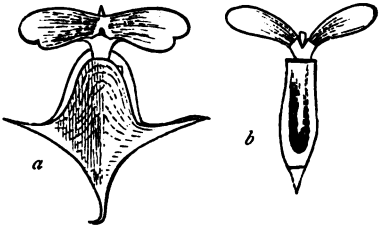


Fig. 93.—Pteropoda. *a Cleodora pyramidata*; *b Cuvieria columnella*. (After Woodward.)

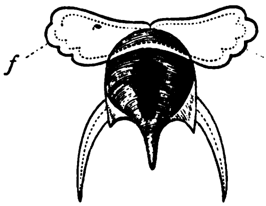


Fig. 94.—*Hyalea tridentata*, showing the shell and the lateral fins attached to the sides of the head (*ff*).

CLASS IV. CEPHALOPODA.—The last and highest class of the *Mollusca* is that of the *Cephalopoda*, comprising the Cuttle-fishes and their allies, together with the Pearly Nautilus. The name of *Cephalopoda* or "head-footed" Molluscs (Gr. *kephalé*, head; *pous*, foot) is derived from the fact that the head is surrounded by a number of processes or "arms" (fig. 95), which enable the animal to creep about head downwards at the bottom of the sea. The Cuttle-fishes can also swim, either by means of fins, or by forcibly emitting jets of water from the mantle-cavity, the reaction driving the animal in the opposite direction. Most of the living Cephalopods possess only an internal skeleton, but the Argonaut (Paper Nautilus) and the

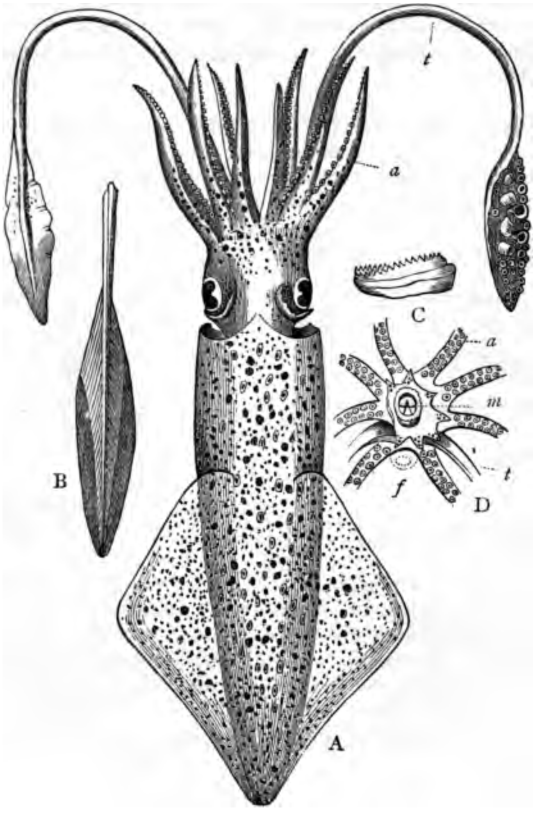


Fig. 95.—A, The common Calamary (*Loligo vulgaris*), reduced in size: *a* One of the ordinary arms; *t* One of the longer arms or "tentacles." B, Skeleton or "pen" of the same, one-fourth natural size (after Woodward). C, Side view of one of the suckers, showing the horny hooks surrounding the margin. D, View of the head from in front, showing the bases of the arms (*a*) and tentacles (*t*), the mouth (*m*), and the funnel (*f*).

Pearly Nautilus have an external shell, though the nature of this is very different in the two forms.

In their structure the Cephalopods are the most highly organised of all the Molluscs. The head (fig. 95) is very distinct, carrying two large globular eyes, and having the mouth in its centre. The mouth is surrounded by eight, ten, or more muscular processes or "arms," which are usually furnished with numerous suckers. By the help of these the animal can seize its prey or can moor itself to some solid object with the utmost tenacity. Generally there are only eight arms; sometimes there are ten, two of these being longer than the others, and carrying suckers only towards their ends (fig. 95). In the Paper Nautilus two of the arms are webbed, and secrete a shell (fig. 97). Lastly, in the Pearly Nautilus (fig. 98) the arms are numerous, more than ten in number, and destitute of suckers.

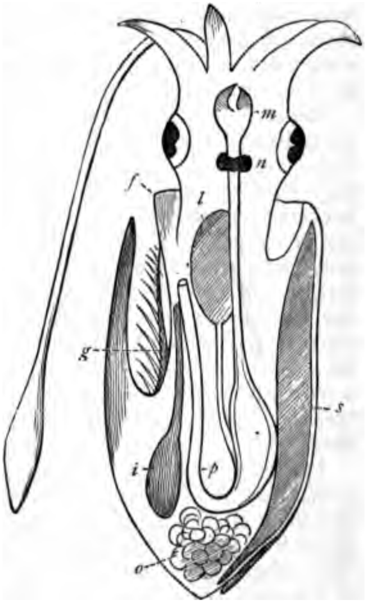


Fig. 96.—Diagram of the internal anatomy of a Cuttle-fish (altered from Huxley). *m* Jaws; *n* Nervous ring surrounding the gullet; *p* Intestine opening at the base of the funnel (*f*); *i* Ink-sac, also opening at the base of the funnel; *g* Gills; *s* Skeleton.

The mouth (fig. 96) conducts into a chamber containing two horny jaws, very like the beak of a parrot, together with a "tongue" or "odontophore." The intestine terminates at the base of a muscular tube which is placed on the under surface of the head, and is known as the "funnel." The funnel communicates with the cavity of the mantle on one hand and the outer water on the other. By the contractions of the muscular mantle, the water contained in the mantle-cavity is driven in jets through the funnel, and the animal is driven in the opposite direction. Through the funnel, also, is emitted the secretion of the "ink-bag," an organ found in all the Cuttle-fishes. It secretes a peculiar inky fluid which the animal can discharge into the water at will, and under cover of which it makes its escape when menaced or pursued. The breathing-organs are in the form of two or four plume-like gills or branchiæ contained within the mantle-cavity. In almost all the living Cephalopods there are only two gills, and these constitute the section *Dibranchiata* (Gr. *dis*, twice; *bragchia*, gill). In the Pearly Nautilus alone of all living Cephalopods there are four gills, and hence, with its fossil relatives, it forms the order *Tetrabranchiata* (Gr. *tetra*, four; *bragchia*, gill). The nervous system of the *Cephalopoda* is highly developed, and the ganglia which correspond to the brain are protected by a cartilage which foreshadows the skull of the Vertebrate animals. The sexes are always distinct, and the process of reproduction is attended with some very singular phenomena, which cannot be noticed here.

The section of the *Dibranchiate Cephalopods*, with two gills, comprises the Cuttle-fishes and their allies, together with the Paper Nautilus. They almost never have an external shell; they have no more than eight or ten arms, furnished with suckers; and they have an ink-bag. When there are ten arms (as in fig 95), two of these are longer than the others, and only carry suckers towards their extremities, which are enlarged and club-shaped. The Cuttle-fishes and their allies the Calamaries are very widely distributed, some frequenting rocky shores, whilst others are found in the open ocean. They are all active and voracious animals, and they sometimes attain a perfectly enormous size. They never have any external shell, but they have a more or less extensively developed internal skeleton.

The only Dibranchiate Cephalopod which possesses an external shell is the Paper Nautilus or Argonaut (fig. 97), and in this the shell is confined to the female. The male is only about an inch in length, and is exactly like the ordinary Cuttle-fishes. The female is considerably larger than the male, and inhabits a beautiful one-chambered shell, which is secreted by the webbed extremities of two of the arms. The shell is not in any way attached to the body, but the webbed arms are turned backwards, and the animal sits in the shell with the "funnel" turned towards the keel. It swims by the jets of water emitted from the funnel, and crawls upon the sea-bottom head downwards carrying its shell upon its back. It is found in the warmer seas of various parts of the world, generally floating at the surface.

The section of the *Tetrabranchiate Cephalopods* comprises those forms which have the body protected by an external many-chambered shell. The arms are more than ten in number, and have no suckers. There are four gills, two on each side of the body; and there is no ink-bag. Very many and beautiful forms of Tetrabranchiate Cephalopods are known as fossils, but the order is represented at the present day by no more than a single living form, the Pearly Nautilus, so well known by its beautiful chambered shell. The shell of the Pearly Nautilus (fig 98) is coiled into a spiral, and is composed of many chambers walled off from one another by curved shelly partitions, perforated centrally by apertures, which transmit a membranous tube or "siphuncle." The separate chambers of the shell are filled with gas, and appear to act as a kind of float, reducing the specific gravity of the shell to near that of the surrounding water. The animal inhabits only the last and largest chamber of the shell, from which it can protrude the head at will. Though the shell is by no means uncommon, very few specimens of the actual animal have hitherto been discovered.

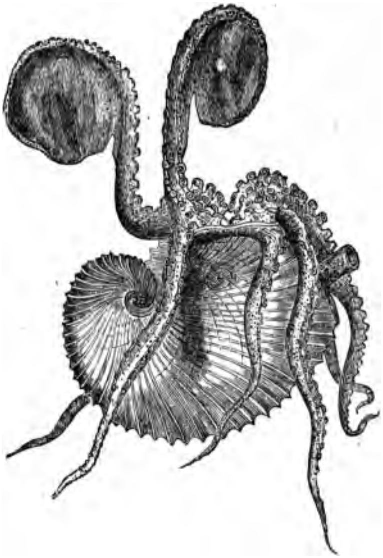


Fig. 97.—*Argonauta argo*, the Paper Nautilus, female. The animal is represented in its shell, but the webbed dorsal arms are separated from the shell, which they secrete, and which they ordinarily embrace.

Amongst the more beautiful and familiar of the fossil relatives of the Pearly Nautilus may be mentioned the *Ammonites* (fig. 99), the shells of which are exceedingly abundant in the so-called Secondary Rocks, and which occur of all sizes, from a little disc no bigger than a split pea up to the dimensions of an ordinary cart-wheel. The genus *Nautilus* is itself an extremely ancient one, and the entire group of the Tetrabranchiate Cephalopods, though now nearly defunct, must have had an amazing development in the past ages of the earth's history.

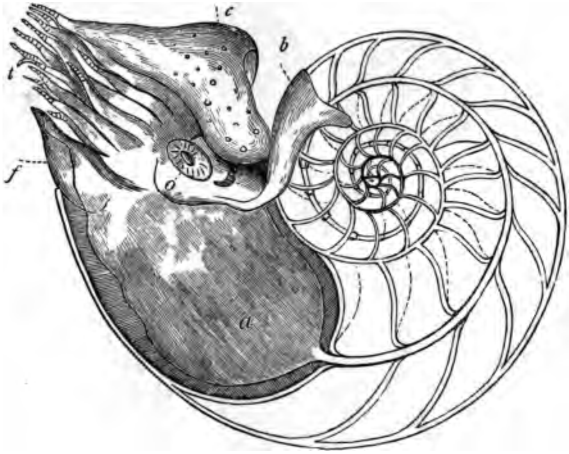


Fig. 98.—The Pearly Nautilus (*Nautilus pompilius*). *a* Mantle; *o* Eye; *t* Tentacles; *f* Funnel.

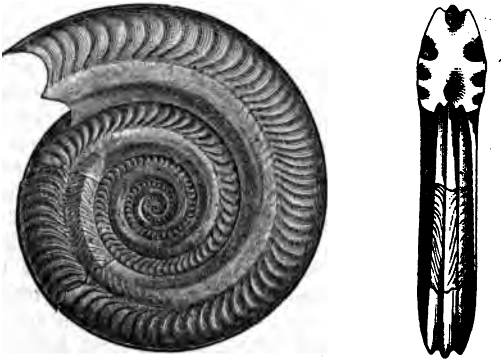


Fig. 99.—*Ammonites bifrons*, from the Lias.

VERTEBRATE ANIMALS.

CHAPTER XVI.

GENERAL CHARACTERS OF THE VERTEBRATA.

As before remarked, the five sub-kingdoms which have now been considered—viz., the *Protozoa*, *Cœlenterata*, *Echinodermata*, *Annulosa*, and *Mollusca*—are commonly grouped together under the name of *Invertebrata*, or Invertebrate animals. To complete our survey of the animal kingdom, there remains only to consider the sixth and last sub-kingdom—that of the *Vertebrata*, or Vertebrate animals.

The sub-kingdom *Vertebrata* includes the five great classes of the Fishes, Amphibians, Reptiles, Birds, and Mammals; and the name of the sub-kingdom is derived from the very general, though not universal, presence of the bony stem known as the "vertebral column," spine, or backbone. In its most complete form the vertebral column consists of a number of separate bony segments, or "vertebræ," arranged so as to form a bony axis within which the part of the nervous system called the "spinal cord" is protected. In some cases, however, the vertebral column is only partially bony, and in other cases it remains permanently and completely in the condition of gristle (cartilage). Lastly, in some cases no vertebral column is ever developed, but the spinal cord is supported by a peculiar gristly, or gelatinous, rod-like structure, consisting of cells enclosed in a fibrous sheath, and termed the "notochord."

Another great peculiarity of Vertebrate animals is shown by making a transverse section of the body, or cutting it in two (fig. 100). If the body of any of the higher Invertebrate animals be cut in two, it is found that the body consists of only a single tube, which encloses all the vital organs, so that the main masses of the nervous system are not in any way shut off or separated from the alimentary canal. This is not the case, however, with the Vertebrate animals. In them, the body, when cut in two (fig. 100, B), exhibits *two* tubes. One of these contains the alimentary canal and heart, with certain portions of the nervous system, whilst the other contains the main masses of the nervous system—namely, the brain and spinal cord.

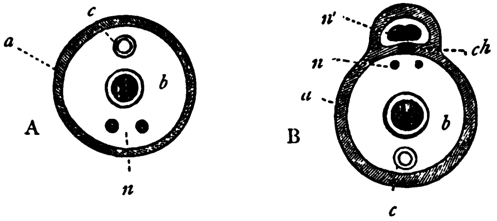


Fig. 100.—A, Diagrammatic section of one of the higher *Invertebrata.* B, Section of one of the *Vertebrata* (slightly altered from Huxley): *a* Wall of the body; *b* Alimentary canal; *c* Circulatory system; *n* Nervous system; *n'* Brain and spinal cord of the *Vertebrata,* enclosed in a separate tube; *ch* Notochord or chorda dorsalis.

The remaining important characters which distinguish the Vertebrate animals as a whole, are the possession of an ***internal*** skeleton to which the muscles are attached, and the fact that there ***are never more than two pairs of limbs,*** which are jointed to the body, and are turned away from that side of the body upon which the main masses of the nervous system are placed.

It will be as well, before proceeding further, to give here a very brief account of the general anatomy of one of the higher Vertebrates, such as a Mammal, and we may advantageously commence with the skeleton. The ***skeleton*** of a Vertebrate animal may be regarded as consisting of the bones which go to form the head and body (trunk) on the one hand, and of those which form the supports for the limbs on the other hand. The bones of the head and trunk may be regarded as essentially composed of a number of bony rings arranged one behind the other. In front these rings are greatly widened out to enclose the brain, and they constitute what is known as the "cranium" or skull (fig. 102). Behind the head the rings are much smaller, and they enclose the spinal cord, whence they are collectively known as the "spinal" or "vertebral column." The rings or segments of the vertebral column are called "vertebræ," and each vertebra (fig. 101) has the following general structure: The central portion of the vertebra is called the "body" (fig. 101, *c*), and gives off two long arches (*n n*), which unite above the body of the bone, and enclose a canal or tube. Both the body and the two arches may give off certain projecting pieces or "processes" which are of great inportance in the study of anatomy, but which need not be particularised here.

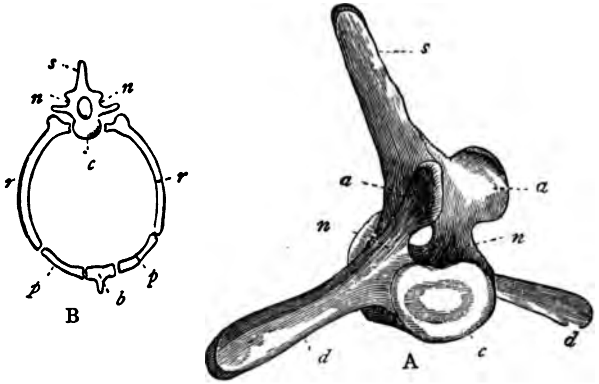


Fig. 101.—A, Vertebra of Whale: *c* Body; *n n* Arches enclosing the spinal cord. B, Diagram of a vertebra in the region of the chest. (After Owen.)

The bodies of the vertebræ are united to one another in such a manner as to give the entire column great flexibility. Further, by the apposition of the canals which are formed by the arches of the vertebræ, a continuous tube is formed, in which the spinal cord is contained, secure from any injury which might befall it in the movements of the vertebral column.

As a general rule, the following *regions* (fig. 102) may be recognised in the vertebral column of the higher Vertebrates:—Firstly, the *cervical region* (Lat. *cervix*, the neck), comprising a variable number of vertebræ which constitute the "neck," and which immediately succeed the head. Secondly, the neck is followed by a varying number of vertebræ which constitute the *dorsal* region (*d*), or region of the back, and which usually carry ribs. Thirdly, the vertebræ of the back are followed by certain vertebræ (*b*) which constitute the *lumbar region*, or region of the loins (Lat. *lumbus*, a loin). Fourthly, there usually follows a series of vertebræ, which are immovably united together so as to constitute a single bone (*s*), which is termed the *sacrum* (Lat. *sacer*, sacred; so called from an ancient superstition concerning it). Finally, there comes a variable series of vertebræ (*t*), which are usually freely movable upon one another, and which constitute the *caudal region*, or region of the tail (Lat. *cauda*, tail).

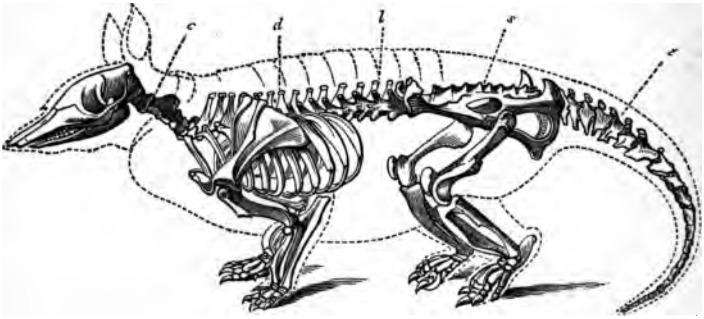


Fig. 102.—Skeleton of the Armadillo, showing the regions of the vertebral column. *c Cervical region*, or neck; *d Dorsal region*, or region of the back; *l Lumbar region*, or region of the loins; *s Sacrum*; *t Caudal region*, or region of the tail.

The cavity of the chest in almost all Vertebrates is bounded by a number of slender curved bones, which are attached behind to the dorsal vertebræ, and which are known as the *ribs* (fig. 91, B). In front the ribs usually unite by cartilages with a bone or chain of bones known as the breast-bone or *sternum*. The sternum, however, is sometimes wanting, and there are sometimes ribs which are not attached to the breast-bone in front.

In examining the *limbs* of the higher Vertebrates, it is at once obvious that the two pairs are constructed upon a similar plan. If we take the highest type of fore limb, as seen in the Mammals (fig. 103), we find it to consist of the following parts: 1. A series of bones connecting the limb to the trunk or body, the two most important being a flattened plate-like bone, the shoulder-blade or *scapula* (*s*), and a rounded slender bone, the collar-bone or *clavicle* (*c*). The former, however, really consists of two distinct bones united together, and the latter is often wanting. 2. The bone which forms the upper arm, and extends from the shoulder to the elbow. This is known as the *humerus* (*h*). 3. The two bones of the fore-arm, which are known as the *radius* (*r*) and *ulna* (*u*). These extend from the elbow to the wrist. 4. A number of little bones (*d*) which constitute the wrist itself, and are called the *carpus*. 5. Several cylindrical bones (properly five in number) which constitute the root of the hand, and are termed the *metacarpus* (*m*). 6. The small cylindrical bones of the fingers themselves, known as the *phalanges* (*p*).

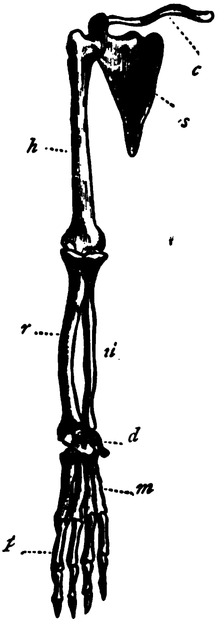


Fig. 103.—Fore limb of Chimpanzee. *c* Collar-bone, or clavicle; *s* Shoulder-blade, or scapula; *h* Humerus; *r* Radius; *u* Ulna; *d* Bones of the wrist, or carpus; *m* Bones of the root of the hand, or metacarpus; *p* Bones of the fingers, or phalanges.

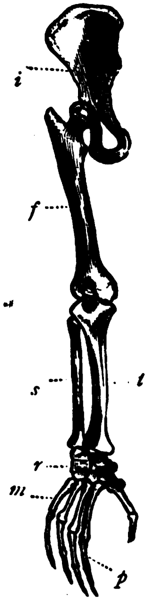


Fig. 104.—Hind limb of Chimpanzee. *i* Innominate bone; *f* Thigh-bone, or femur; *t* Tibia; *s* Fibula; *r* Bones of the ankle, or tarsus; *m* Metatarsus; *p* Phalanges.

Similar parts are found in the hind limb of a Mammal (fig. 104), but here they have different names. The bones which connect the hind limb to the body are amalgamated together, and they form on each side a single bone termed the *innominate bone* (*i*). This is succeeded by the single long bone which forms the thigh, and is known as the thigh-bone or *femur* (*f*).

Below this are the two bones of the shank or leg proper, known as the *tibia* or shin-bone (*t*) and the *fibula* (*s*). These are followed by a number of small bones which constitute the ankle-joint, and are termed the *tarsus* (*r*). This in turn is succeeded by several cylindrical bones (properly five in number) which constitute the root of the foot, and are termed the *metatarsus* (*m*). These are finally succeeded by the bones of the toes or *phalanges* (*p*). By comparing the two illustrations with one another, the general correspondence between the bones of the fore and hind limbs will be at once evident. The student, however, must bear in mind that very often one or both of the two pairs of limbs proper to the Vertebrates may be so modified to suit some particular purpose, that the above-mentioned parts may cease to be recognisable, or may be very difficult to trace.

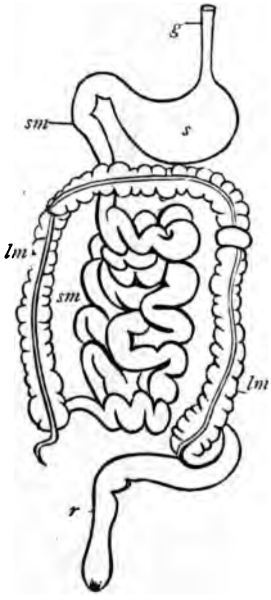


Fig. 105. — Digestive system of a Mammal. *g* Gullet; *s* Stomach; *sm* Small intestine; *lm* Large intestine; *r* Termination of the large intestine.

As to the *digestive system* of Vertebrates (fig. 105), the food is conducted to the stomach by a muscular tube termed the gullet (*g*). In the stomach the food becomes to a great extent digested by the action upon it of the fluid secreted by this organ. From the stomach the food passes into a long convoluted muscular tube, which is known as the "small intestine" (*sm*). Here it is mixed with the "bile" secreted by the liver, and also with the fluid secreted by another gland called the "pancreas." The small intestine finally opens into a tube of much larger diameter, which is called the "large intestine" (*lm*). The large intestine always terminates in a distinct vent, by which the indigestible portions of the food are got rid of.

The result of the entire process of the digestion of the food is the formation of a nutritive fluid, the *blood*. With the single exception of one little fish (the Lancelet), the blood in all Vertebrate animals is red in colour, when viewed in mass. This is due to the presence in it of innumerable microscopical particles, which are termed the "blood-corpuscles," the fluid in which these float being colourless, or nearly so. In the subjoined illustration (fig. 106) are represented some of the forms of blood-corpuscles which are found in different classes of the *Vertebrata.* The blood is always distributed through the body by means of a system of closed tubes which constitute the "blood-vessels;" and in all, except the Lancelet, it is propelled by a contractile muscular cavity or "heart."

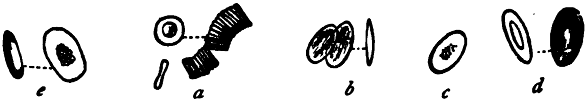


Fig. 106.—Blood-corpuscles, magnified. *a* Man; *b* Goose; *c* Crocodile; *d* Frog; *e* Skate.

Distinct *breathing-organs* are present in all the Vertebrates, but the nature of these differs according with the mode of life. In the aquatic or semi-aquatic Fishes and Amphibians, there are always *gills* or branchiæ, adapted for breathing air dissolved in water. Hence these classes are often spoken of collectively as the "Branchiate" Vertebrates. Some of the Fishes, however, have lungs as well as gills, and in all the Amphibians lungs are finally developed, either in addition to the branchiæ or to their total exclusion. The Reptiles, Birds, and Mammals, on the other hand, never possess gills, and they are therefore often spoken of as the "Abranchiate" Vertebrates. In place of gills they possess *lungs,* in the form of spongy organs, which are placed in the chest, and receive air through a tube opening in the throat, and termed the "windpipe" or *trachea.*

The *nervous system* varies very much in its development in different Vertebrates. In the singular little fish the Lancelet, the main mass of the nervous system consists of a cord of nervous matter, representing the spinal cord, but not enlarged in front into a distinct brain. In all other Vertebrates the central masses of the nervous system consist of a nervous cord (the spinal cord), which is contained in the canal formed by the arches of the vertebræ, and of a larger or smaller mass of nervous matter, which is placed in front of the spinal cord, is termed the "brain," and is contained within the skull. Part, however, of what is commonly called the "brain" really belongs to the spinal cord.

Reproduction in all Vertebrate animals is by means of the sexes, which, except in some Fishes, are always in different individuals; and in no case are compound organisms or colonies produced by budding or cleavage. Most are *oviparous*, producing eggs, from which the young are produced; but some retain the eggs within the body till the young are ready to be hatched, and these are sometimes said to be *ovo-viviparous*. The higher Vertebrates, however, bring forth their young alive, and are said to be *viviparous* (Lat. *vivus*, living; and *pario*, I bring forth).

The sub-kingdom Vertebrata is divided into the following five great classes :—

1. *Pisces* (Fishes).
2. *Amphibia* (Frogs, Newts, &c.)
3. *Reptilia* (True Reptiles).
4. *Aves* (Birds).
5. *Mammalia* (Mammals).

CHAPTER XVII.

CLASS I. PISCES.

THE Fishes form the lowest class of the *Vertebrata*, and they are distinguished by being cold-blooded, by being always possessed of gills, and by having their limbs, when present, in the form of fins or expansions of the integument.

The body in fishes is mostly so shaped as to allow of rapid movement in their natural element, water, and it is generally covered with a protective covering of scales. These integumentary appendages differ a good deal in shape, but four principal kinds have been distinguished and named by the celebrated naturalist Agassiz :—

1. *Cycloid* scales (fig. 107, *a*), consisting of thin, horny, flexible scales, having a smooth rounded outline. These scales occur in most of our common fishes.

2. *Ctenoid* scales (fig. 107, *b*), resembling the last in texture, but having their hinder margin fringed with spines or comb-like projections.

3. *Placoid* scales (fig. 107, *c*), consisting of scattered bony grains, tubercles, or plates, which are often armed with pro-

jecting spines. A good example of these is to be found in the common Thornback.

4. *Ganoid* scales (fig. 107, *e*), composed of two layers, an under layer of bone, and an upper layer of hard polished enamel. These scales are not common amongst existing fishes, but examples are found in the Pipe-fish of our own seas and the Bony Pike of North America.

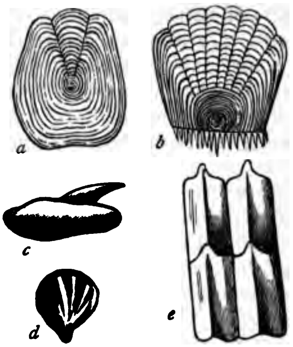


Fig. 107.—Scales of Fishes. *a* Cycloid scale (Pike); *b* Ctenoid scale (Perch); *c* Placoid scale (Thornback); *d* Placoid scale of *Rhina*; *e* Ganoid scales (*Palæoniscus*).

The true internal skeleton of fishes is very complicated, and little can be said about it here. In many fishes the vertebral column never becomes converted into bone, or only very partially so, but remains in its original condition of cartilage or gristle. This is the case with the Lampreys, the Skates, Sturgeons, and many others. In most ordinary fishes, however, the spinal column (fig. 108) becomes converted into bone, and, with one exception, the vertebræ are always cup-shaped or hollow at both ends. The result of this is, that there is formed

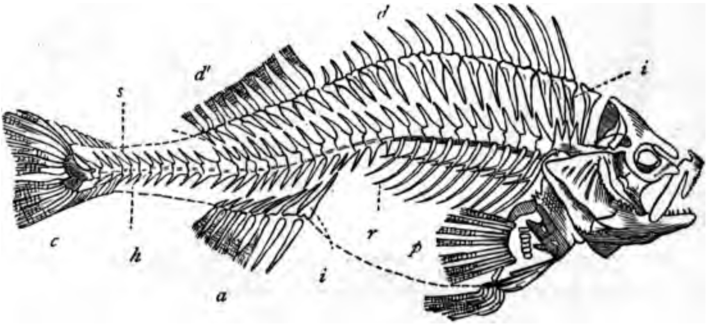


Fig. 108.—Skeleton of the common Perch (*Perca fluviatilis*). *p* One of the pectoral fins; *v* One of the ventral fins; *a* Anal fin, supported upon interspinous bones; *c* Caudal fin; *d* First dorsal fin; *d'* Second dorsal fin; *i i* Interspinous bones.

between each pair of vertebræ a doubly-conical cavity, which is filled with a gelatinous substance; and in this way extreme flexibility is given to the whole spinal column.

The *limbs* of fishes may be wholly absent, or there may be only one pair, but there are never more than two pairs. The limbs of fishes, with the exception of the Mud-fish, are converted into *fins*, and hence they differ very much in form and structure as compared with the limbs of the higher Vertebrates. They consist, namely, of expansions of the integument, supported by numerous bony or gristly supports or rays (fig. 108); this structure rendering them capable of striking against the water, and thus of acting as swimming-paddles. The pair of limbs which correspond to the arms of man and the fore limbs of other Vertebrates are placed on the "shoulders" of the fish, just behind the gill-slits, and they are termed the *pectoral* fins (figs. 108, 109, *p*). The hind limbs in fishes are very variable in their position, and they are called the *ventral* fins (figs. 108, 109, *v*).

As the pectoral and ventral fins represent the fore and hind limbs, it follows that, when they are present at all, there are always *two* of each. They are therefore spoken of as the "paired" fins. Besides these, however, there is also a series of what are called "median" fins, which must in no way be confounded with the paired fins. The median fins are placed in the middle line of the body, and they are *unpaired*, having no fellows. They agree with the paired fins in consisting of ex-

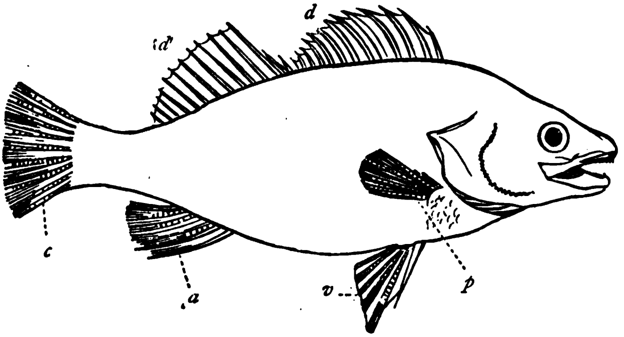


Fig. 109.—Outline of a Fish (*Perca granulata*), showing the "paired" and "median" fins. *p* One of the pectoral fins; *v* One of the ventral fins; *d* First dorsal fin; *d'* Second dorsal fin; *a* Anal fin; *c* Caudal fin.

pansions of the integument supported by "rays," but they differ from them in the fact that their rays are carried upon the heads of a peculiar series of bones, known as the "interspinous bones" (fig. 108, *i i*). These are dagger-shaped bony spines which are embedded in the middle line of the body of the fish. The "median" fins are variable in number, and sometimes there is only a single fringe running round the hinder end of the body. Commonly, however, the median fins consist of one or two expansions placed upon the back, and called the "dorsal" fins (fig. 109, *d*, *d'*); one or two upon the lower surface near the vent, called the "anal" fins (*a*); and a broad fin clothing the extremity of the spinal column, and known as the "caudal" fin or tail (*c*). The tail-fin is the chief organ of progression of the fish, and it is placed vertically, so as to strike the water from side to side, and not horizontally, as in the Whales and Dolphins. In most living fishes the tail is composed of two equal lobes which spring from the end of the spine (fig. 110, A), when it is said to be "homocercal." In a few living fishes, however, and in many fossil forms, the tail is unsymmetrical, being unequally lobed (fig. 110, B). In these cases the spinal column is prolonged into the upper lobe of the tail, and the tail is said to be "heterocercal."

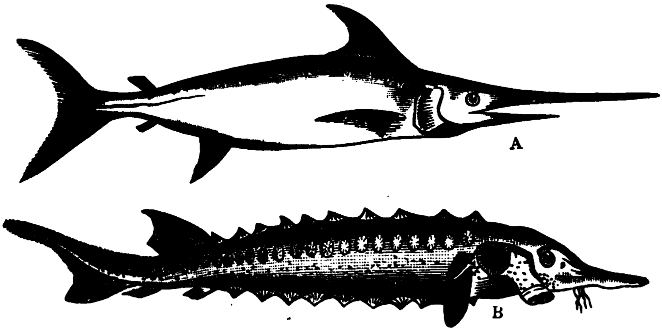


Fig. 110.—A, Sword-fish, showing homocercal tail; B, Sturgeon, showing the heterocercal form of tail.

As regards the digestive system of fishes, the mouth is usually furnished with a very complicated series of teeth, which are placed not only upon the jaws, but often upon any or all of the bones which enter into the composition of the mouth. The intestinal canal is usually short, but the liver is generally of large size and saturated with oil.

In all fishes except the Lancelet, the breathing organs are in the form of gills or branchiæ, the exact form and arrangement of these differing considerably in different fishes. In most fishes, however, the gills (fig. 111) are in the form of a number of pointed leaflets arranged on bony or cartilaginous arches which are connected with the tongue-bone below and with the lower surface of the head above. The gills are placed in a chamber on each side of the neck of the fish, and the water is admitted to them from the mouth by a series of openings or fissures in the throat. The water is taken in by a process very like that of swallowing, and, after passing over the gills, it makes its escape behind by a single opening on the side of the neck, called the "gill-slit." The gill-slit can be opened at will, and is covered in by a kind of folding-door composed of a chain of flat bones, called the "gill-cover." The gill-slit is also partially covered below by a membrane supported upon a variable number of slender bony spines.

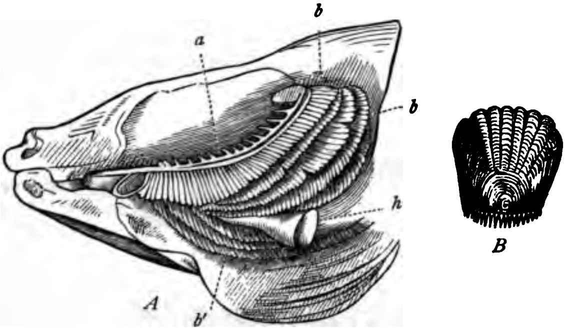


Fig. 111.—A, Gills and heart of the Perch exposed by the removal of the gill-cover on the left side: *a* First of the four bony arches which carry the gills (*b b*); *b'* The lower edges of the gills on the right side; *h* Heart (after Van der Hoeven). B, Scale of the Perch, magnified.

Whilst respiration in all the typical fishes is carried on by means of gills, most are, nevertheless, furnished with an organ which is called the "swim-bladder" or "air-bladder," and which doubtless corresponds to the lungs of the higher Vertebrata. It is a membranous bag, placed below the spine, and filled with gas, acting mainly as a kind of float. Sometimes it is quite closed, but in other cases it opens into the gullet by a tube which corresponds with the wind-pipe. In the Mud-fishes (*Dipnoi*) the air-bladder is double, and is actually concerned with carrying on the function of respiration, so that in these fishes the air-bladder truly becomes a lung.

The heart in fishes mostly consists of only two chambers, and is concerned with driving the impure or venous blood to the gills. The blood is cold — that is to say, little or not at all warmer than the medium in which the animal lives. The blood-corpuscles (fig. 106, *e*) are furnished with a solid particle in their interior, or are "nucleated," and, except in the Lancelet, most of them are red.

The nervous system is of a comparatively low type of organisation, and the brain is of small size. The essential parts of the organ of hearing are always present, but in none is there any direct communication between the ear and the outer world, though sometimes traces of such may be detected. The nose does not open behind into the throat, except in the Hag-fishes and the Mud-fish, and the sense of smell must be far from acute.

Lastly, as regard their mode of reproduction, most fishes are truly *oviparous*, but some are ovo-viviparous. The ovaries of the female fish are commonly called the "roe."

CHAPTER XVIII.

ORDERS OF FISHES.

THE known number of fishes is so great, and their forms and habits so various, that it will be sufficient merely to give the leading peculiarities of the six orders into which the class is divided. The classification here adopted is the one proposed by Professor Huxley.

ORDER I. PHARYNGOBRANCHII (Gr. *pharugx*, the upper part of the gullet; *bragchia*, gill).—This order includes only a single little fish, the Lancelet (*Amphioxus*), the characters of which differ very greatly from those of the more highly organised Fishes. The Lancelet (fig. 112) is a little, worm-like, semitransparent fish, from one and a half to two inches long, found burrowing in sand-banks in various seas. It has no "paired" fins, representing limbs, but there is a narrow median fin and a lancet-shaped caudal fin. There are no jaws or teeth, but the mouth is surrounded by a number of cartilaginous filaments. The mouth opens into a great chamber, the walls of which are perforated by numerous ciliated slits or fissures. This sac acts as a breathing-organ, and takes the place of gills. There is no heart, but the blood is propelled by pulsating dilations of several of the great blood-vessels. The blood itself is colourless. There is no vertebral column, but the spinal cord rests upon a semi-gelatinous rod (notochord); and the spinal cord does not expand in front so as to form a distinct brain.

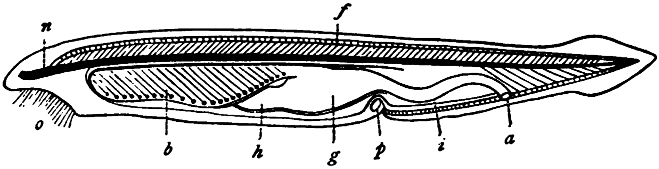


Fig. 112.—The Lancelet (*Amphioxus lanceolatus*), enlarged to twice its natura size. *o* Mouth; *b* Respiratory chamber, with its ciliated fissures; *g* Stomach; *h* Pouch representing the liver; *i* Intestine; *a* Anus; *n* Notochord; *f* Rudiments of fin-rays; *p* Abdominal pore.

ORDER II. MARSIPOBRANCHII (Gr. *marsipos*, a pouch; *bragchia*, gill).—This order includes the eel-like Lampreys and Hag-fishes (fig. 113), and derives its name from the pouch-like arrangement of the gills. The gills, namely, are not placed all together in a chamber on each side of the neck as in most common fishes, but they are situated in a number of distinct sacs or pouches, which receive water from the throat, and open externally by a number of separate openings placed on the side of the neck (fig. 113). This arrangement allows these fishes to fix themselves to any solid object by their mouths, so that they are not obliged to take in water by the mouth. There is no lower jaw in these fishes, and the mouth forms a kind of suck-

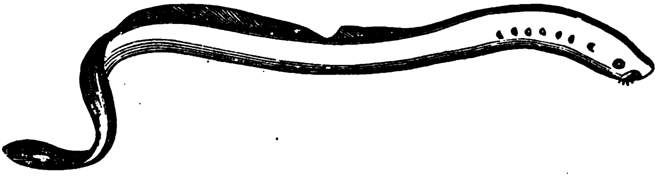


Fig. 113.—River Lamprey or Lampern (*Petromyzon fluviatilis*), showing the openings of the gill-pouches on the sides of the neck.

ing-cup. There are no pectoral or ventral fins, or, in other words, there are no limbs. The skull is cartilaginous, and the vertebral column is only represented by the notochord.

The Hag-fish (*Myxine*) is an eel-like fish, which is generally found embedded in the interior of some large fish, into which it has penetrated by means of a single serrated fang attached to the centre of the palate. A curious fact about the Hag-fish is that the nose communicates with the mouth by a tube which perforates the palate.

The Lampreys are found both in fresh and salt water; some of them are often eaten. In these the cavity of the nose is closed, and does not communicate behind with the throat, as is the case in the Hag-fishes.

ORDER III. TELEOSTEI (Gr. *teleios*, perfect; *osteon*, bone).—This order comprises the so-called "Bony" fishes, including most of the commoner forms of the class. As implied by their name, the skeleton is generally completely bony, and there is a vertebral column consisting of distinct vertebræ, hollow at both ends. The Bony fishes are the most typical members of the class, and most of their peculiarities have been mentioned in speaking of the fishes generally. It will be enough, therefore, to state here, that in addition to the characters just mentioned, the Bony fishes are distinguished by the following points: 1. The skull consists of distinct bones, and a lower jaw is present. 2. The scales are mostly "cycloid" and "ctenoid," and are only rarely "ganoid." 3. The fore and hind limbs are

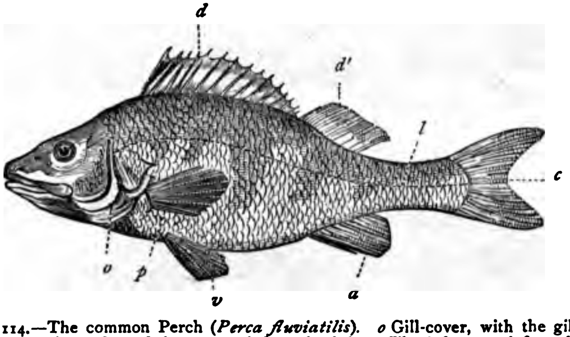


Fig. 114.—The common Perch (*Perca fluviatilis*). *o* Gill-cover, with the gill-slit behind it; *p* One of the pectoral fins, the left; *v* The left ventral fin; *d* The first dorsal fin; *d'* The second dorsal fin; *c* The caudal fin or tail; *a* The anal fin; *l* Lateral line.

usually, but not always, present, when they are known as the pectoral and ventral fins. 4. Median fins exist besides the paired fins. 5. The tail consists of two equal lobes, or is "homocercal." 6. The respiratory organs are in the form of comb-like or tufted gills placed in two chambers situated on the sides of the neck. Each gill-chamber opens externally by a single vertical "gill-slit," protected by a "gill-cover" (fig. 114, *o*), and a membrane supported by bony rays. 7. The nose does not communicate behind with the throat.

Amongst the more important families of this large order of fishes may be mentioned the Eels (*Murænidæ*), the Herrings (*Clupeidæ*), the Pikes (*Esocidæ*), the Salmon and Trout (*Salmonidæ*), the Cod and Haddock family (*Gadidæ*), the Flat-fishes (*Pleuronectidæ*), the Perch family (*Percidæ*), and the Mackerels (*Scomberidæ*).

ORDER IV. GANOIDEI (Gr. *ganos*, splendour or brightness).—The Ganoid fishes agree with the Bony fishes in the form of the gills and gill-covers, but the ossification, or conversion into bone, of the skeleton is often imperfect; and the body is generally protected externally by *ganoid* scales or plates—*i.e.*, by scales consisting of an inferior layer of bone, and a superior layer of polished enamel (fig. 115). These ganoid scales are not peculiar to the Ganoid fishes, but are very characteristic of them. The skull in the Ganoids is composed of distinct bones,

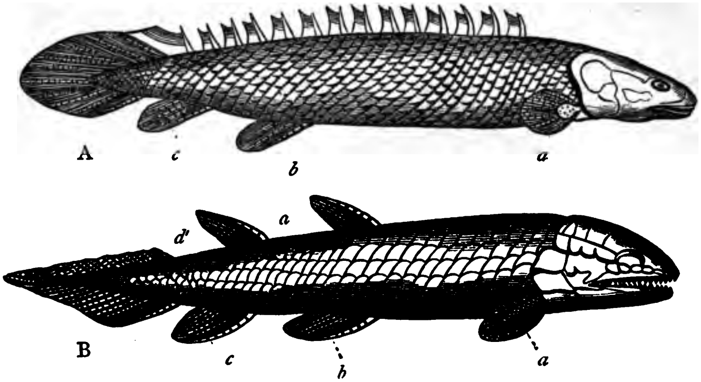


Fig. 115.—Ganoid Fishes. A, *Polypterus*, a living Ganoid. B, *Osteolepis*, a fossil Ganoid. *a* Pectoral fin; *b* Ventral fin; *c* Anal fin; *d, d'* Dorsal fins.

and there is a lower jaw. The pectoral and ventral fins are usually present, and the latter are placed very far back. The tail-fin is unsymmetrical or "heterocercal."

There are few living Ganoid fishes, but very many fossil forms are known to geologists. Of the living forms, the best known are the *Polypterus* (fig. 115, A) of the rivers Nile and Senegal, the Bony Pike of North America, and the Sturgeons. The true Sturgeons (fig. 110, B) are the most familiar and most important of the living Ganoids. They mostly attain a very large size, and are chiefly found in the North Sea, the Caspian, and the Black Sea, being captured when ascending the great rivers for the purpose of spawning. The swim-bladder of the Sturgeons is one of the chief sources from which *isinglass* is prepared; and the roe is largely sold as a delicacy under the name of *caviare.*

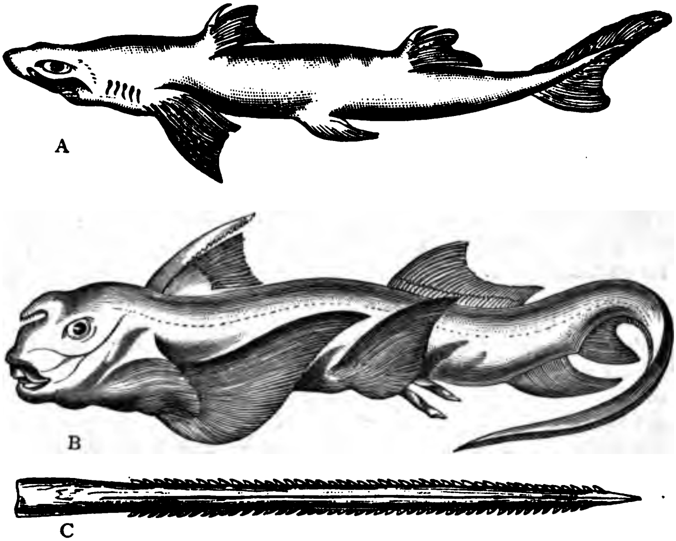


Fig. 116.—A, *Spinax acanthias*, one of the Dog-fishes. B, *Chimæra monstrosa.* C, Tail-spine of an Eagle-Ray (*Myliobatis*).

Order V. Elasmobranchii (Gr. *elasma*, a thin plate; *bragchia*, gill).—The best-known members of this order are the Sharks, Dog-fishes, and Rays, and the leading character of the order is to be found in the nature of the gills, which are fixed, and form a number of pouches. These pouches communicate internally with the throat, and in most cases open externally on the side of the neck by means of as many apertures as there are pouches (fig. 116, A). In some cases, however, as in the *Chimæra* (fig. 116, B), though the structure of the gills is the same, there is only a single external aperture. The skull is not composed of distinct bones, the vertebral column is usually cartilaginous, and the skin is furnished with *placoid* scales —*i.e.*, with detached bony tubercles, granules, or plates. The pectoral and ventral fins are present, and the latter are placed very far back.

In the Sharks and Rays the mouth is placed on the under surface of the head, and there are several apertures to the gills. In the *Chimæra* and its allies the mouth is placed at the end of the head, and there is only a single external gill-aperture. The Sharks and Dog-fishes are common in all oceans, and are extremely voracious animals. The Rays are distinguished from the Sharks by having a flattened body, and some of them attain an enormous size.

ORDER VI. DIPNOI (Gr. *dis*, twice; *pnoē*, breath).—This order includes the singular Mud-fishes (*Lepidosiren*, fig. 117), which are natives of South America and Africa. The name of the order is derived from the fact that the respiratory organs are twofold, consisting of gills and of true lungs. In this respect the Mud-fishes approach the next class of the Amphibians, and the resemblance is further increased by the fact that some of the Mud-fishes possess *external* gills, as well as the internal set. The nose, also, opens behind into the throat, as is the case in no other fishes except the Hag-fishes.

The body in the Mud-fish is fish-like and covered with horny scales, the two pairs of limbs are present in the form of awl-shaped organs, and the tail is furnished with a vertical tail-fin. The Mud-fishes inhabit marshy tracts, and appear to be able in the dry season to bury themselves in the mud, and to form a kind of nest in which they remain dormant till the rains of the wet season set them free.

In addition to the Mud-fishes of America and Africa, a new and very remarkable fish of the same group has recently been discovered in the rivers of Queensland, Australia. This singular fish (fig. 118) has been termed *Ceratodus Forsteri*, and resembles the Lepidosirens in its general form, in its possession of horny cycloid scales, in the character of its tail-fin, and in the twofold nature of its breathing organs. It differs, however, from the Lepidosirens in various points, and especially in having the ventral and pectoral fins formed of a central scaly lobe surrounded by the fin-rays—a character which it possesses in common with a well-marked group of Ganoid Fishes, comprising both recent and extinct forms.

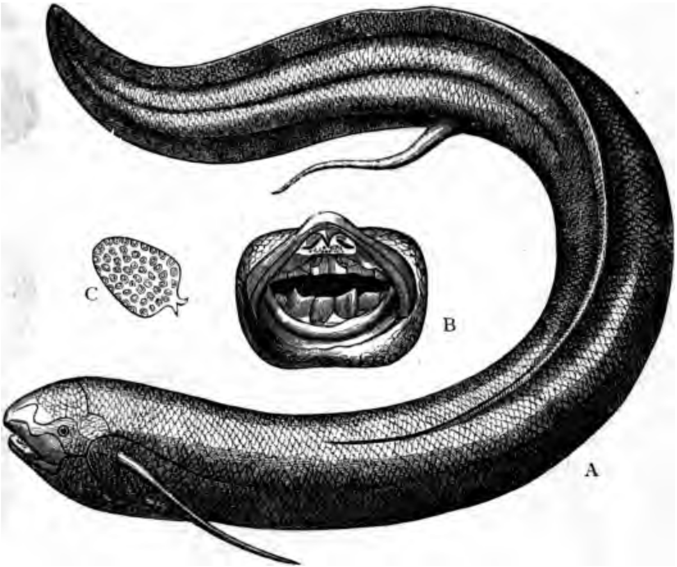


Fig. 117.—A, *Lepidosiren paradoxa*, one of the Mud-fishes; B, Front of the mouth of the same, showing the teeth; C, One of the overlapping scales, enlarged.

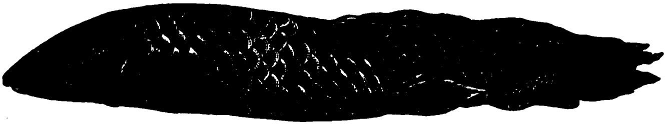


Fig. 118.—*Ceratodus Forsteri*, the Australian Mud-fish.

CHAPTER XIX.

CLASS II. AMPHIBIA.

THE class *Amphibia* comprises the Frogs and Toads, the Newts and Land-salamanders, the *Cæciliæ*, and some extinct forms; and the great and distinguishing character of the class is the fact that the animal undergoes a kind of change or metamorphosis in passing from the young to the adult condition. In the great majority of cases, as in the common Frog (fig. 119), the Amphibians commence life as water-breathing "larvæ," commonly known as Tadpoles. In this condition they possess a long fish-like tail, and are furnished with gills or branchiæ, adapted for breathing air dissolved in water (fig. 119, *a*, *b*). They spend a certain length of time in this fish-like condition, but ultimately true lungs are always developed, and the animal then becomes capable of living on land. In some cases, as in the Axolotl (fig. 120), the external gills are retained throughout life, and do not disappear when the lungs are developed. In other cases, again, the gills disappear when the lungs are produced, and the animal is then only capable of breathing air directly. This occurs in the Newts and Frogs;

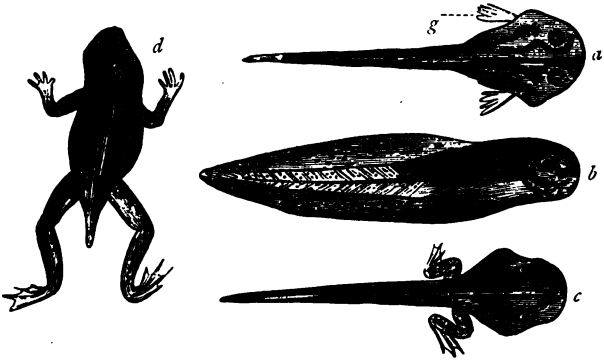


Fig. 119.—Development of the common Frog. *a* Tadpole, showing the external gills, viewed from above; *b* The same, viewed from the side; *c* Older specimen, in which the hind legs have made their appearance; *d* Specimen in which all the limbs have appeared.

but another difference is observable as to the development of these. In the Newts (fig. 122), the long tail of the Tadpole or "larva" is retained throughout life, and the animal remains permanently a "tailed" Amphibian. In the Frogs and Toads, however, the larval tail is cast off before the animal attains maturity, and the adult is a "tail-less" Amphibian (fig. 123). This change from an aquatic to an aerial mode of respiration is, then, the leading character of the *Amphibia*, and it is from this that the name of the class is derived (Gr. *amphi*, both; *bios*, life). The adult, however, is obviously not strictly *amphibious*, unless, like the Axolotl, it retains its gills throughout life.

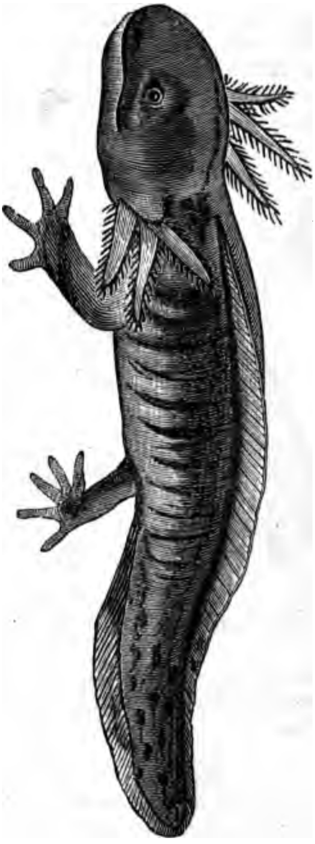


Fig. 120.—The Axolotl (*Siredon pisciforme*), showing the persistent external branchiæ (after Tegetmeier).

The *Amphibia*, then, are "branchiate" Vertebrates, and agree with the Fishes in always possessing gills at some time or other of their life. They differ from all the fishes, except the Mud-fish, in always possessing true lungs when grown up; and they differ from all fishes in never having the limbs converted into fins, and in never having "median" fins supported by bony or gristly "rays." They are further characterised by the fact that the skull is jointed to the vertebral column by *two* joints (or "condyles"); the heart of the adult is three-chambered; and the nose opens behind into the throat.

The class Amphibia is divided into three living orders as follows:—

1. *Ophiomorpha.*
2. *Urodela.*
3. *Anoura.*

Order I. Ophiomorpha (Gr. *ophis*, a serpent; *morphe*, form).—This order includes only certain worm-like or snake-like Amphibians, which are termed *Cæciliæ*, and are found burrowing in marshy ground in India, Africa, and South America. They possess no limbs (fig. 121), and have only rudimentary eyes, and though very like the true Snakes, they have gills when young, and are therefore undoubted Amphibians. They sometimes attain a length of several feet.

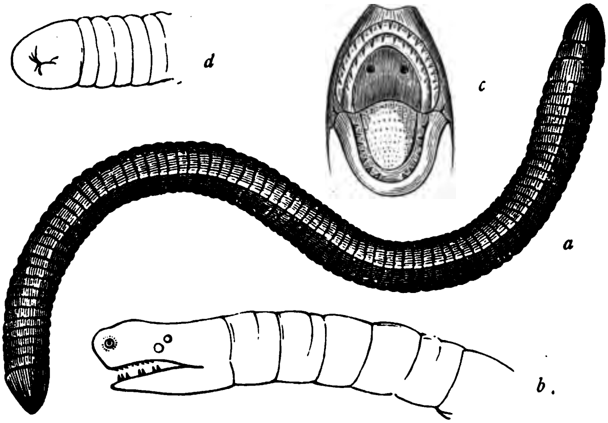


Fig. 121.—Ophiomorpha. *a Siphonops annulatus*, one of the Cæcilians, much reduced: *b* Head; *c* Mouth, showing the tongue, teeth, and internal openings of the nostrils; *d* Tail and cloacal aperture. (After Dumeril and Bibron.)

Order II. Urodela (Gr. *oura*, tail; *delos*, visible).—This section includes the so-called "tailed" Amphibians, such as the Newts and Salamanders, in which the tail of the tadpole does not fall off when maturity is reached, but is permanently retained throughout life (fig. 122). As a general rule, both the fore and hind limbs are developed, but the latter may be wanting. Owing to the presence of two pairs of limbs and a long tail, the *Urodela* are not uncommonly confounded with the *Lizards*; but the latter are true Reptiles, and never possess gills at any time of life.

In some of the *Urodela* the gills are permanently retained throughout life, as is the case with the Axolotl (fig. 120). This curious Amphibian inhabits the Mexican lakes, and attains a length of a foot or more. More remarkable than the Axolotl, and also keeping the gills throughout life, is the *Proteus*, which is found inhabiting the waters of certain caves in Illyria and Dalmatia. It attains a length of about a foot, and from its living in darkness the eyes are completely rudimentary.

In other *Urodela*, as in our common Newts (fig. 122), the gills disappear before maturity is reached, and both pairs of limbs are present. The Newts are adapted for an aquatic life, and have a compressed fish-like tail. Several species are known as inhabiting our own country, and every one probably is acquainted with their appearance. The Land-salamanders are nearly related to the Newts, but they live upon the land, and have a rounded cylindrical tail.

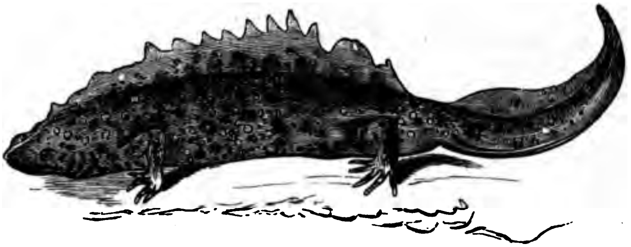


Fig. 122.—Great Water-newt (*Triton cristatus*)—after Bell.

ORDER III. ANOURA (Gr. *a*, without; *oura*, tail).—This order comprises the Frogs and Toads, or so-called "tail-less" *Amphibia*, the adult wholly losing the long tail which is present in the young (fig. 123). The adult is also destitute of gills, and respiration is carried on wholly by the lungs, assisted to a greater or less extent by the skin. The young, however, or tadpoles, have gills, and possess a long fish-like tail (fig. 119).

In the Toads (*Bufonidæ*) there is a tongue, but the jaws are not armed with teeth. In the Surinam Toads (*Pipidæ*) there are rarely teeth, and there is no tongue. In the true Frogs (*Ranidæ*) the upper jaw always carries teeth, and there is a tongue, like that of the Toads, fixed to the front of the mouth, and free behind, so that it can be protruded at will. The typical Frogs (fig. 123) have enormously-developed hind legs, the toes of which are united by membrane, or are "webbed."

They swim very powerfully, and can take extensive leaps. The Tree-frogs, on the other hand, are adapted for a wholly different life, inhabiting trees, amongst which they climb with great ease by the help of suckers developed upon the ends of all the toes. They are mostly found in warm countries, especially in America, but one species is European.

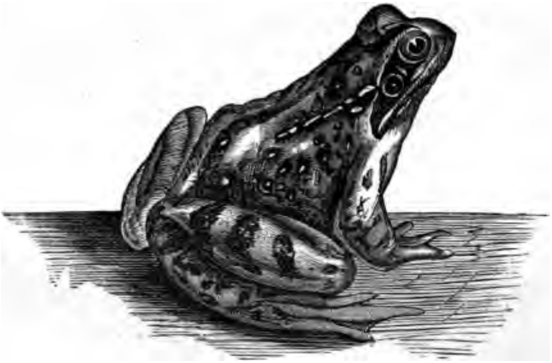


Fig 123 —The common Frog (*Rana temporaria*).

FOSSIL AMPHIBIANS.—Amongst the various Amphibians which are known in a fossil state, there is one group which may just be mentioned here. This is the group of the "Labyrinthodonts," so called from the peculiarly complicated structure of their teeth (Gr. *laburinthos*, a labyrinth; *odous*, tooth). These animals chiefly abounded at the time when the coal was formed, and in the period of the new red sandstone, and some of them must have attained an enormous size, the skull of one species being over three feet in length. They appear to have been "tailed," and the lower surface of the body had a kind of armour formed of bony plates, whilst the head was defended by polished shields of bone. Their footprints have been often preserved (fig. 124), and are remarkable for their singular resemblance in shape to the human hand.

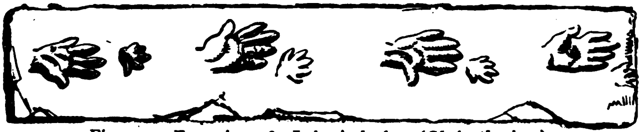


Fig. 124.—Footprints of a Labyrinthodont (*Cheirotherium*).

CHAPTER XX.

CLASS III. REPTILIA.

WITH the true Reptiles we commence the series of the "abranchiate" Vertebrates, or of those Vertebrate animals which never at any time of life are possessed of gills or branchiæ. The blood is cold, like that of the preceding classes, and the blood-corpuscles are nucleated (fig. 106, *c*). The heart in most Reptiles is three-chambered, but is sometimes four-chambered. In all, however, the body is not supplied with pure arterial blood, but with a mixture of arterial with impure venous blood; hence the low temperature and generally sluggish character of these animals. The skull in the true Reptiles, unlike that of the *Amphibia*, is united to the vertebral column by a single joint (or condyle), and each half of the lower jaw is composed of several pieces. The skin has the power of secreting horny scales, with or without bony plates, but in no case do the appendages of the integument take the form of feathers. The limbs may be altogether wanting, as in the Snakes—or rudimentary, as in some Lizards; but in most Reptiles both pairs of limbs are present. In no case, however, are the fore limbs constructed upon the type of the "wing" of Birds. Lastly, all Reptiles are oviparous or ovo-viviparous.

The class *Reptilia* is divided into four living and six extinct orders, of which the former only will be considered here. The living orders are:—

1. *Chelonia* (Tortoises and Turtles).
2. *Ophidia* (Snakes).
3. *Lacertilia* (Lizards).
4. *Crocodilia* (Crocodiles).

ORDER I. CHELONIA.—The members of this order are well known as Tortoises and Turtles, and are characterised by the fact that the jaws are not provided with teeth, and the body is enclosed in a double bony case or box. The jaws in all the Chelonians are encased in horn, so as to constitute a kind of beak like that of a bird, and in only a few instances are lips present. The case in which the body is protected is double, and is composed partly of flattened bones belonging to the true skeleton and partly of bony plates developed in the lower layer of the integument; the whole being covered by horny plates, or sometimes by a leathery skin. The case is essentially made up of a superior shield called the "carapace" (fig. 125, *ca*), and a lower or ventral shield, called the "plastron." The carapace

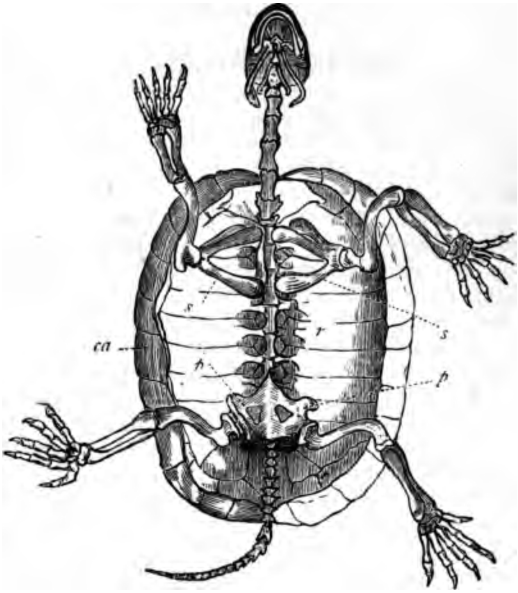


Fig. 125.—Skeleton of a Tortoise, seen from below, the plastron having been removed. *ca* Carapace.

and plastron are united along their edges, but leave apertures for the protrusion of the head, tail, and limbs; and the bones connecting the limbs with the spine are placed under the carapace.

The Chelonians are conveniently divided into groups, according as the limbs are adapted for swimming, for progression on land, or for an amphibious life. The aquatic forms are well known as Turtles, distinguished by having the carapace depressed, and the limbs converted into oar-like flippers, with which the animal swims. The two most important of the Turtles are the edible Green Turtle and the Hawk's-bill Turtle (fig. 126). The former of these is found in many of the seas of warm climates, and is largely imported into Europe as a delicacy. The latter is of considerable commercial value, from the horny scales which cover the carapace, and which are so largely employed for ornamental purposes under the name of "tortoise-shell."

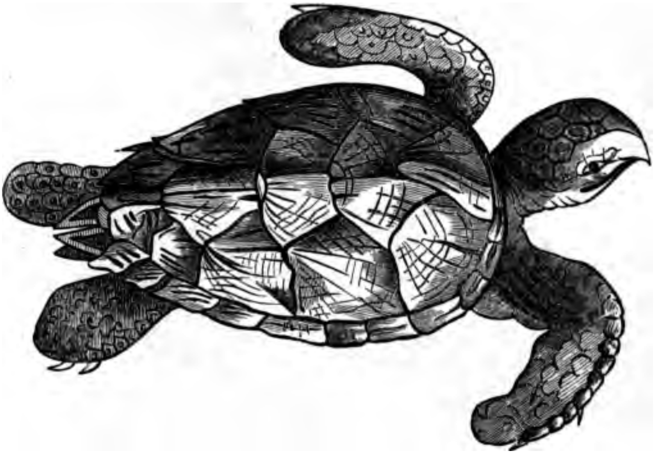


Fig. 126.—Hawk's-bill Turtle (*Chelone imbricata*)—after Bell.

The Land-tortoises have a rounded and convex carapace, and have indistinct toes furnished with short claws. The most familiar species in this country is the *Testudo Græca*, which is often kept as a domestic pet.

The Pond and River Tortoises are furnished with webbed feet, and lead a semi-aquatic existence. The latter have the carapace covered with a leathery skin, without horny scales, and are therefore often called "Soft Tortoises."

ORDER II. OPHIDIA.—This order includes most of the animals which would commonly be called Snakes or Serpents, the most striking peculiarities of which are to be found in the nature of the organs of locomotion. The body is always more or less elongated, worm-like, or cylindrical (fig. 127), and there are no visible limbs. The fore limbs are altogether and universally wanting, and the hind limbs are almost always also absent. In a few cases, however, there are rudimentary traces of the existence of hind limbs. There is never any breast-bone, but the ribs are exceedingly numerous, and the

Snakes progress rapidly by means of these, walking, as it were, upon the ends of the ribs, the great flexibility of the vertebral column much assisting in this. The skin in the Snakes develops horny scales, but bony plates are never produced in it.

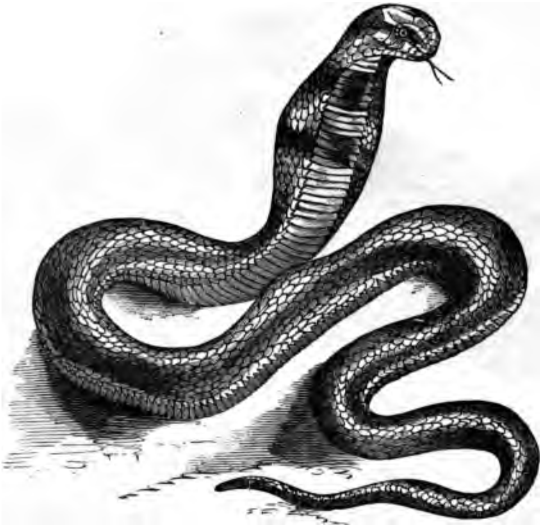


Fig. 127.—The *Naja Haje*, a poisonous snake of Egypt.

The tongue in Serpents is forked, and consists of two muscular cylinders united towards their bases. It can be protruded and retracted at will, and is probably more an organ of touch than of taste. The eye in Serpents is not protected by movable eyelids, but is covered by a pellucid membrane composed of the outer layer of the skin; hence the fixed and unwinking stare of these animals.

Hooked conical teeth are always present, but they are not sunk in distinct sockets, and are only used to hold the prey, and not in chewing it. All the arrangements of the mouth in Serpents are adapted to the fact that they live upon animals which they catch, and that they swallow their food without dividing it or chewing it. To this end the two halves of the lower jaw are merely loosely united to one another by ligaments and muscles; and they are connected with the skull by a bone which is also movable. The result of this is, that the Snakes can open the mouth to an extraordinary width, and they can perform the most astonishing feats in the way of swallowing. In the harmless Snakes the teeth are solid, and are arranged in rows in both jaws and on the palate. In the poisonous Snakes, on the other hand, the upper jaws are usually destitute of the ordinary solid teeth, but carry a pair of long curved "poison-fangs" (fig. 128). The poison-fangs are pointed backwards when not in use, but they can be erected at will by muscular action, the moment the animal wishes to bite. Each poison-fang is hollow, and is perforated by a fine tube or canal, opening by a distinct aperture at the point of the fang. The canal of the fang communicates with a gland placed under and behind the eye (fig. 129), which secretes the fluid which renders the bite of these Snakes dangerous or deadly. When the animal strikes its prey, the poison-fangs are erected, and as their points

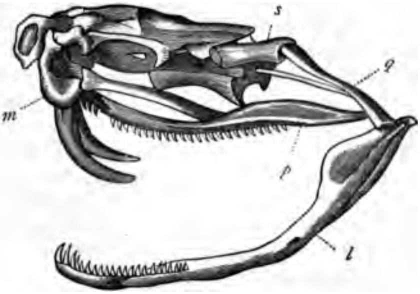


Fig. 128.—Skull of the Rattlesnake (after Dumeril and Bibron). *l* One-half of the lower jaw united to the skull by the quadrate bone (*q*); *m* Upper jaw, carrying the poison-fangs; *p* Series of teeth upon the palate.

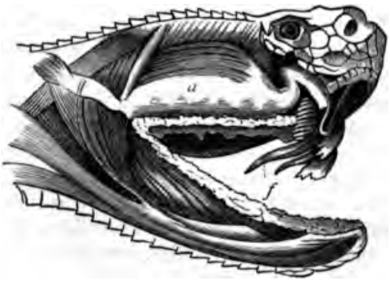


Fig. 129.—The head of the Rattlesnake, dissected to show the poison-gland (*a*) and poison-fangs (*f*)—after Duvernoy.

enter the flesh a drop of fluid is forced through the canal of the fang into the wound. In the Viperine Snakes the upper jaws carry no other fully grown teeth except the poison-fangs, but in other venomous Snakes the upper jaws carry small teeth in addition to the poison-fangs.

Of the non-venomous harmless Snakes, we have an excellent example in the common Ringed Snake (*Coluber natrix*) of this country. It lives upon small animals, such as Frogs, and often takes to the water, swimming rapidly and gracefully. In this respect, however, it is excelled by the poisonous Water-Snakes (*Hydrophidæ*), which live in flocks at the mouths of rivers, and are specially adapted to an aquatic life by the possession of a compressed swimming-tail. Some of the non-venomous Snakes are rendered highly dangerous by their great size and enormous muscular power. Their bite is harmless, but they kill their prey by coiling themselves round it and gradually tightening the folds. Of this nature are the Pythons and Boas of hot climates, which are certainly known to exceed twenty feet in length, and which are said sometimes to attain a much greater size.

The poisonous Snakes are familiarly known to us by the common Viper (*Pelias berus*), which occurs commonly in this country. It is a harmless animal, unless trodden on or otherwise irritated, and its bite, though dangerous, is rarely fatal. Other notorious venomous Serpents are the Rattlesnake of America, the Hooded Snake of India, and the Puff-adder of South Africa.

ORDER III. LACERTILIA.—This order comprises the ordinary Lizards, and some snake-like animals, such as the Blind-worm of Britain. The *Lacertilia* are distinguished from the Snakes by *usually* having four well-developed limbs, and by the fact that the two halves of the lower jaw are united in front much more firmly than in the Ophidians. The eyes, too, are mostly furnished with movable eyelids. The Lizards are distinguished, on the other hand, from the Crocodiles, by not having their teeth implanted in distinct sockets, and by the fact that the skin develops horny scales, but never bony shields.

Of the snake-like Lizards a good example is to be found in the common Blind-worm or Slow-worm (fig. 130) of our own country. Its appearance is completely snake-like, and it is vulgarly regarded as a dangerous and venomous animal. It is, however, perfectly harmless and inoffensive, not even having the power of piercing the human skin. It lives upon worms, insects, and snails, and can be easily kept in captivity. It is remarkable in the fact that when alarmed it stiffens its muscles to such an extent that the tail can readily be broken off, as if it were brittle.

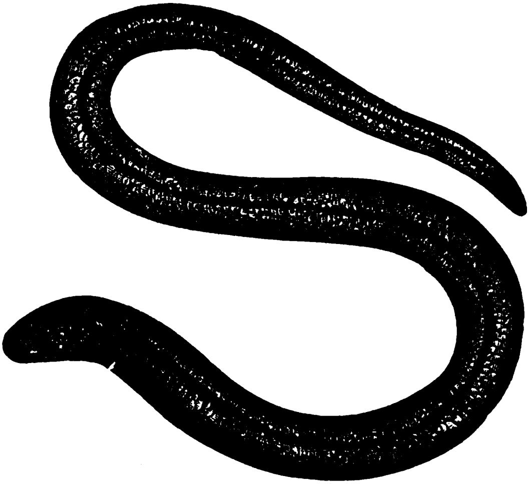


Fig. 130.—Blind-worm (*Anguis fragilis*)—after Bell.

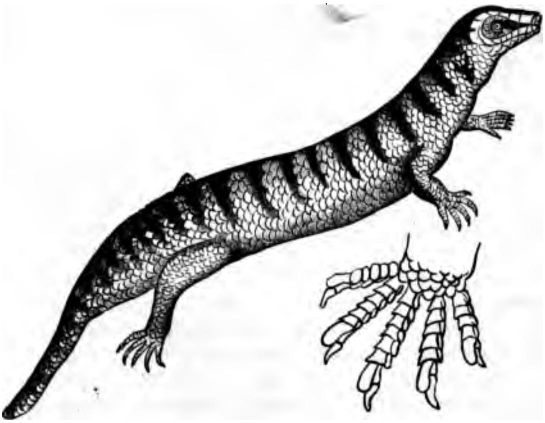


Fig. 131.—The Skink (*Scincus officinalis*).

As a good example of the typical Lizards with four well-developed legs, we may take the Skink (fig. 131), which is extremely common in Egypt and Arabia. It is from eight to nine inches in length, and was formerly used as a remedy in various diseases. The only Lizard, except the Blind-worm, which can be said to be at all common in England, is the Sand-lizard (*Lacerta agilis*), but this is also of small size. The largest of the living Lizards are the Monitors, which are exclusively found in the Old World, and attain a length of from six to eight feet. Very large, too, are the Iguanas of the American continent, which often reach a length of several feet.

ORDER IV. CROCODILIA.—The *Crocodilia* are distinguished from other Reptiles by the possession of teeth implanted in separate sockets, and by the fact that the skin not only develops horny scales, but in addition produces bony plates, which form a covering for the upper surface of the body (fig. 132).

The Crocodiles abound in the fresh waters of hot climates, and are the largest of existing Reptiles, not uncommonly attaining a length of sixteen feet or more. The best known of the *Crocodilia* is the Nilotic Crocodile, which occurs abundantly in Egypt, and was described by both Herodotus and Aristotle. Little less familiar are the Alligators or Caimans, which often attain a length of fourteen feet, and are of common occurrence in many parts of America, and are found also in China. In the great rivers of Hindostan, also, is found the Gavial or Gangetic Crocodile, remarkable for the great length and slenderness of its snout. All the Crocodiles are dangerous and voracious brutes, and many instances are on record in which human beings have been injured or killed by them in crossing rivers or in bathing.

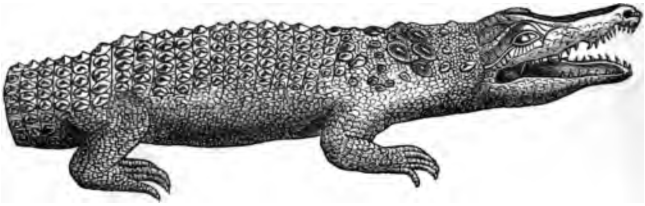


Fig. 132.—Head and fore-part of the body of the common Crocodile (*Crocodilus Niloticus*).

FOSSIL REPTILES.—A vast number of fossil Reptiles are known, many of which differ most strikingly from any existing types, and present phenomena of great interest. Two or three of the more important of these extinct Reptiles may just be mentioned in this place. Foremost amongst them are the great marine Reptiles to which the name of *Ichthyosaurus* (Gr. *ichthus*, fish; *saura*, lizard) has been given. The *Ichthyosauri* attained a gigantic size, and in many respects resemble the existing Crocodiles (fig. 133). They possess, however, the remarkable peculiarity that both the fore and hind legs were flattened out so as to form swimming-paddles very similar in construction to the "flippers" of Whales and Dolphins. The *Plesiosauri* (Gr. *plesios*, near; *saura*, lizard), like the *Ichthyosauri*, attained enormous dimensions, and also lived in the sea, being furnished similarly with flattened swimming-paddles (fig. 134). The head of *Plesiosaurus* was, however, comparatively small, and it was set upon the extremity of a long swan-like neck. All these great marine Reptiles had the jaws furnished with long pointed teeth, and must have been the tyrants of the seas of the "Secondary Period," in which they lived.

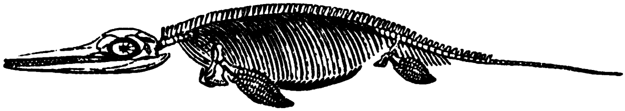


Fig. 133.—*Ichthyosaurus communis.*

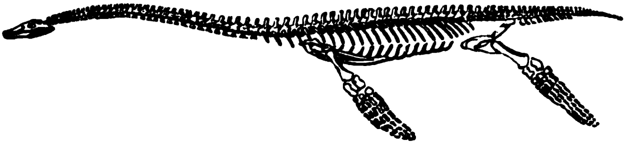


Fig. 134.—*Plesiosaurus dolichodeirus.*

Even more curious than the preceding are the wonderful flying Reptiles to which the name of "Pterodactyles" (Gr. *pteron*, a wing; *daktulos*, a finger) has been given. In some respects these animals form a kind of connecting link between the Reptiles and the Birds, and they even recall the Mammalian order of the Bats. They are, however, undoubted Reptiles in most of their characters, in spite of the fact that they could fly. This power they owed, not to wings like those of Birds, but to the possession of a great flying-membrane, supported between the side of the body, the hind and fore limbs, and the enormously lengthened outer finger (fig. 135). They had pointed teeth in the jaws, and were doubtless voracious in their habits.

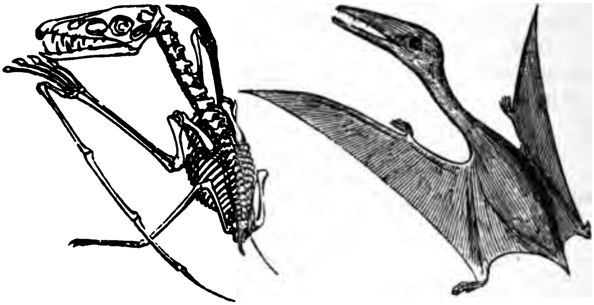


Fig. 135.—*Pterodactylus brevirostris.* Skeleton and restoration.

They belong to the Secondary Period of Geology, and vary in size from about as big as a pigeon, up to an expanse of wing of between twenty and thirty feet.

CHAPTER XXI.

CLASS IV. AVES.

THE fourth class of Vertebrate animals is that of the Birds or *Aves*, which may be shortly defined as being "oviparous Vertebrates, with warm blood, a double circulation, and a covering of feathers" (Owen). Besides these characters, the majority of the blood-corpuscles are nucleated (fig. 106, *b*), the skull is jointed to the spinal column by a single joint (condyle), the jaws are destitute of teeth, the fore limbs are modified so as to form "wings," and the lungs communicate with a number of air-sacs scattered through the body.

The feathers, which form such a distinctive character of Birds, are formed by a modification of the outer layer of the skin; and a typical feather, such as one of the quill-feathers of the wing or tail, consists of the following parts: 1. A horny cylindrical tube, which forms the lowest part of the feather, and is termed the "quill." 2. The "shaft," which forms the central axis of the feather, and consists of a horny sheath filled with a white spongy substance. 3. The "webs," which form the lateral expansions of the feather, and are attached to the sides of the shaft. Each web is composed of a number of small branches or "barbs," which in turn carry still smaller fibres or "barbules." As a rule, the barbs are kept in connection with one another by means of the barbules, the ends of which are hooked. Towards the base of the shaft, however, the barbs are more or less separate, and constitute what is known as the "down." In the Ostriches, and the birds allied to them, all the barbs are separate from one another, and approach to the characters of hairs.

The skeleton of Birds exhibits many points of peculiar interest, mostly in adaptation to an aerial mode of life; but it will be sufficient here to notice the structure of the fore-limb or "wing," and the bones by which the fore-limb is connected with the trunk (fig. 136, A). The breast-bone (*b*) in all birds which fly is furnished with a prominent ridge or "keel," to

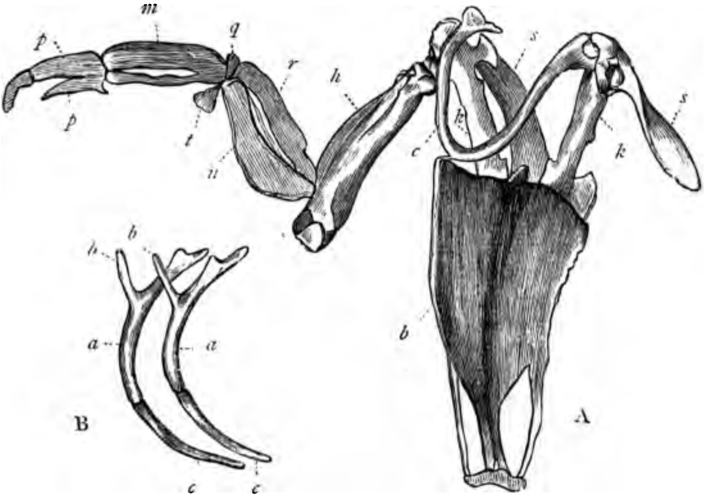


Fig. 136.—A, Breast-bone, shoulder-girdle, and fore-limb of Penguin (after Owen): *b* Breast-bone with its keel; *s s* Shoulder-blades; *k k* Coracoid bones; *c* Furculum or merry-thought, composed of the united collar-bones; *h* Humerus; *r* Radius; *u* Ulna; *q* Wrist; *t* Thumb; *m* Metacarpus; *p* Phalanges of the fingers. B, Ribs of the Golden Eagle.

which are attached the great muscles which move the wings. The size, therefore, of this keel gives a good indication of the strength of flight in any given instance; and in birds which do not fly, like the Ostrich, there is no keel upon the breast-bone. The bones which connect the fore-limbs with the trunk are the two shoulder-blades, the two "coracoid bones," and the so-called "furculum" or "merry-thought." The two shoulder-blades (*s s*) exhibit no special peculiarity. The so-called "coracoid bones" are the representative of what is part of the shoulder-blades in most mammals; but in Birds they are not only separate bones, but are the strongest bones of the shoulder-girdle. They form two strong pillars (*k k*), which rest upon the breast-bone below, and support the downward stroke of the wing. The "furculum" or "merry-thought" (*c*) is a V-shaped bone, which keeps the wings at their proper distance from each other, and which is really composed of the united collar-bones or clavicles. The bone of the upper arm or humerus (*h*), and the bones of the fore-arm or radius and ulna (*r*, *u*) offer no special peculiarity. The wrist or carpus (*q*) is, however, reduced to two small bones; the metacarpus (*m*) is also reduced to two bones, which are joined at their extremities; and the digits are reduced to a rudimentary thumb (*t*) and two fingers (*p*). (To understand the differences between the fore-limb of a Bird and that of a Mammal, the student should refer to the general description of the limbs of Vertebrates, p. 146, fig. 103.)

No living Birds have teeth, but the jaws are sheathed in horn, constituting the "beak." The tongue is usually hard and horny, but is sometimes soft and fleshy, as in the Parrots. The gullet (fig. 137, *o*) is usually dilated in the lower part of the neck into a pouch (*c*) called the "crop." Shortly after leaving the crop, the gullet opens into a second cavity, which is the true digesting stomach, and is called the "proventriculus" (*p*). This in turn opens into a muscular cavity which is called the "gizzard" (*g*), and which leads into the small intestine (*sm*). In those birds which live on hard substances, such as the grain-eating species, the gizzard is extremely thick and muscular, and its inner lining is hard and horny. In these birds the gizzard constitutes a kind of grinding apparatus, like the stones of a mill; whilst the "crop" may be compared to the "hopper" of the mill, since it supplies to the gizzard "small successive quantities of food as it is wanted" (Owen). The grinding action of the gizzard is further assisted by the small pebbles and gravel which, as is well known, so many birds are in the habit of swallowing. The commencement of the large intestine is furnished in most birds with two blind tubes or "cæca" (*k*). These vary considerably in length in different birds, and their exact function is questionable.

Respiration is effected in Birds more completely and extensively than in any other class of Vertebrate animals, in consequence of the fact that air is admitted not only to the lungs, but also to a series of air-receptacles scattered through various parts of the body. The lungs, namely, of Birds communicate with a series of membranous sacs, which vary in number and position in different cases, but serve in all alike both to reduce the specific gravity of the body, and to assist in the aeration of the blood. Further, the air is admitted from these air-receptacles into a number of air-cavities in the interior of a greater or less number of the bones. In young Birds, these air-cavities in the bones do not exist, and the bones are simply filled with marrow as in the Mammals. In Birds, also, which do not fly, there are either no air-cavities in the bones or very few.

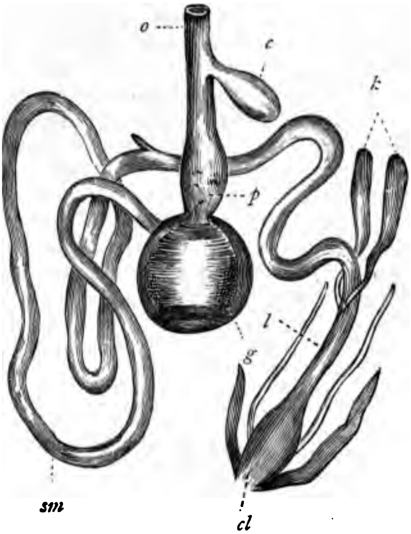


Fig. 137.—Digestive system of the common Fowl (after Owen). *o* Gullet; *c* Crop; *p* Proventriculus; *g* Gizzard; *sm* Small intestine; *k* Intestinal cæca; *l* Large intestine.

The heart in Birds is four-chambered, and the circulation is double, as it is in Mammals. In other words, the heart is a double organ, one side being wholly concerned with propelling the pure arterial blood through the body, whilst the other is occupied in driving the impure venous blood through the lungs.

The organs of the senses, with the exception of touch and taste, are well developed in Birds, vision especially being generally extremely acute. Eyes are always present, and the form of the eye is maintained by a circle of bony plates. In addition to the ordinary upper and lower eyelids, Birds possess a third membranous eyelid,—the *membrana nictitans*—which is placed on the inner side of the eye, and can be drawn over the front of the eye like a curtain. The sense of smell is apparently seldom very acute in Birds, and the nostrils are usually placed on the sides of the upper mandible of the bill.

Finally, all Birds are strictly *oviparous.* The egg is always enclosed in a calcareous shell, and is developed after expulsion from the body by a process of "incubation" or "brooding"—a process for which Birds are especially adapted, in consequence of the high average temperature of the body.

CHAPTER XXII.

ORDERS OF BIRDS.

THE class *Aves* is divided into the following seven living orders, each of which must be briefly considered :—

1. *Cursores* or Running Birds.
2. *Natatores* or Swimming Birds.
3. *Grallatores* or Wading Birds.
4. *Rasores* or Scratching Birds.
5. *Scansores* or Climbing Birds.
6. *Insessores* or Perching Birds.
7. *Raptores* or Birds of Prey.

ORDER I. CURSORES.—The Running or Cursorial Birds, comprising the Ostrich, Cassowary, Emeu, Rhea, and Apteryx, are characterised by the rudimentary condition of the wings, which are useless as organs of flight, and by the compensating length and strength of the legs. In accordance with this condition of the limbs, the bones have few air-cells, and the breastbone is destitute of the prominent ridge or keel, to which the muscles of flight are attached in the birds which fly. The legs are extremely powerful, and the hinder toe is wanting in all except the *Apteryx* (fig. 138), in which it is present in a rudimentary condition. The front toes are either two or three in number, and are furnished with strong blunt claws. The feathers are peculiar in the fact that the barbs are separate, and are not united to one another by the barbules.

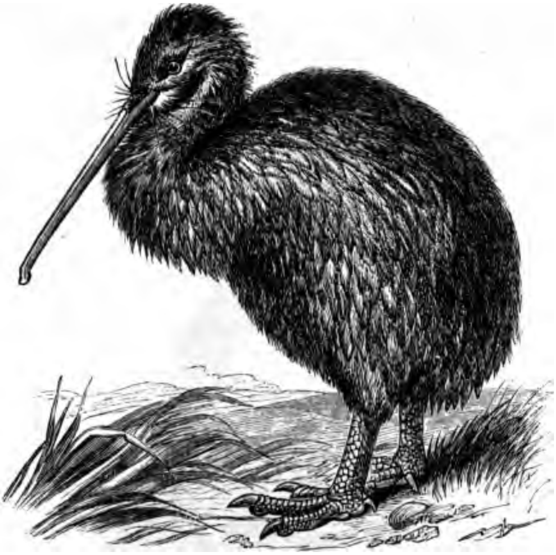


Fig. 138.—The *Apteryx Australis* of New Zealand, showing the hair-like feathers and the rudimentary great toe on the back of the foot.

The African Ostrich (*Struthio camelus*) inhabits the desert plains of Africa and Arabia, and is the largest of living birds, attaining a height of from six to eight feet. The feet have only two toes each, but the legs are extremely powerful, and the Ostrich can run with extraordinary speed. The American Ostriches or Rheas are much smaller than the true Ostriches, and the feet have three toes each. They inhabit South America. The Emeu is exclusively confined to New Holland, and nearly equals the Ostrich in height. The Cassowaries inhabit New Guinea, and some of the islands of the Pacific

Archipelago. The *Apteryx*, the last of the living Cursorial Birds, is a native of New Zealand, and is remarkable in having the nostrils placed at the very extremity of the upper mandible of the bill.

ORDER II. NATATORES.—The order of the Swimming Birds comprises birds which are adapted for a more or less completely aquatic life. The body (fig. 139) is boat-shaped, the neck long, and the legs short and placed behind the point of equilibrium of the body; this position admirably adapting the feet to act as oars, but rendering the gait upon dry land comparatively awkward and shuffling. The toes are always more or less completely webbed, or united to one another by a membrane. From their living much in the water, the Natatorial Birds are exposed to great reductions of temperature, and for this reason the plumage is very dense, and is always kept well oiled, so as to keep the wet out.

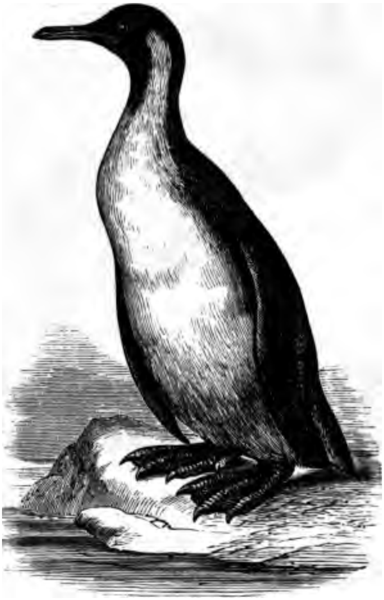


Fig. 139.—Penguin (*Aptenodytes patagonica*).

The Swimming Birds, as their name implies, are all more or less completely at home in the water, sometimes much more so than they are on the land. Some of them, such as the Penguins (fig. 139) and Auks, have the wings very small or quite rudimentary; and others, such as the Divers, Guillemots, and Grebes, have wings which are but slightly more developed. On the other hand, the Gulls, Terns, and Petrels have long and pointed wings, and are birds of powerful flight; and the same is the case with the Cormorants, Frigate-birds, and Pelicans. The Ducks, Geese, and Swans form a well-marked group of the Natatorial Birds, distinguished by having the bill flattened, and covered by a soft skin, and its edges are furnished with a series of plates (fig. 140, A) which form a kind of a "strainer," by means of which these Birds sift the mud in which they habitually seek their food. The foot in this group (fig. 140, B) is webbed, but the hinder toe is free.

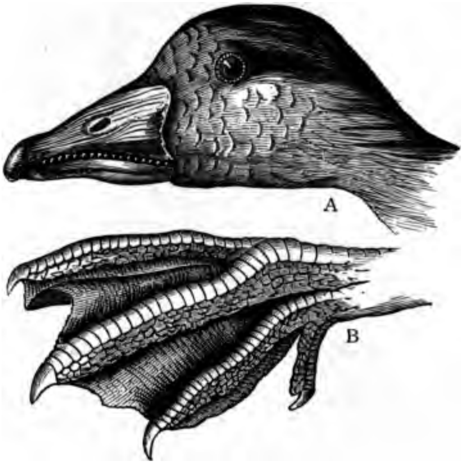


Fig. 140.—A, Head of the Grey Lag Goose; B, Foot of the domestic Goose.

ORDER III. GRALLATORES.—The Wading Birds mostly spend their time wading about in shallow water, feeding upon small fishes, shell-fish, worms, and insects. Many, however, live chiefly upon the dry land, and are more or less exclusively vegetable feeders. They are distinguished by the great length of the legs (fig. 141), which are also unfeathered—as far, at any rate, as the lower end of the tibia. The foot has three toes in front and usually one behind, but the toes are never completely webbed. The wings are long and the power of flight considerable, but the tail is short, and its function as a rudder is chiefly transferred to the long legs, which are stretched out behind in flight. The bill is almost always of considerable length, and is usually more or less pointed.

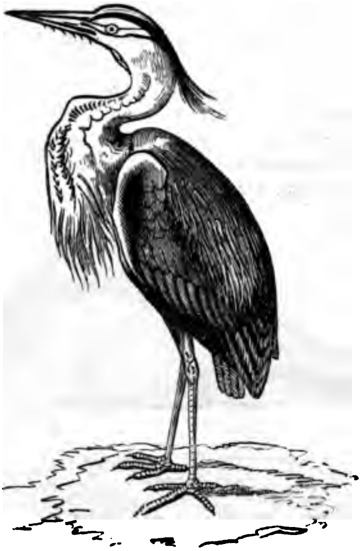


Fig. 141.—Common Heron (*Ardea cinerea*).

Amongst the more important Wading Birds may be mentioned the familiar Water-rail, Corn-crake, and Water-hens of our own country, the elegant Herons, Egrets, and Bitterns, the brilliantly-coloured Ibises, the Stork and Adjutant, the long-billed Snipes, Woodcocks, Sandpipers, and Curlews, and the two groups of the Plovers and the Bustards.

ORDER IV. RASORES.—The Scratching Birds—or, as they are often called, the Gallinaceous Birds—are characterised by having the upper mandible of the bill convex, and having a membranous space at its base in which the nostrils are pierced. The nostrils are also defended by a cartilaginous scale. The feet have four toes each, three in front and a short hind toe;

and in the typical forms the toes are provided with strong blunt claws suitable for scratching. The feet of the Pigeons, however, are generally adapted for perching.

The Rasorial Birds are divided into two very well-marked groups. In the first of these are the Fowls, Pheasants, Grouse, Guinea-fowl, Turkey, Pea-fowl, and other allied birds. In the second group are the Pigeons and Doves (fig. 142), distinguished by the fact that the feet are slender and adapted for perching, whilst the voice is of a gentle, soft, and melancholy character. The Fowls and Game-birds, on the other hand, are mostly terrestrial in their habits, and have strong feet, with claws not suited for perching on trees, whilst their voice is of a harsh and dissonant nature, and their flight is comparatively feeble.

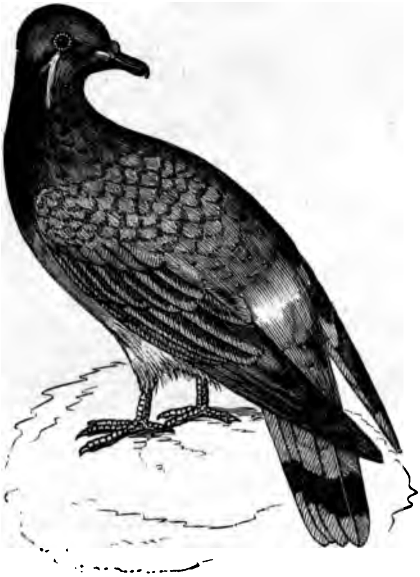


Fig. 142.—Rock Pigeon (*Columba livia*).

ORDER V. SCANSORES.—The Climbing Birds are distinguished by the fact that the feet have four toes each, of which two are turned backwards and two forwards (fig. 143). This arrangement of the toes enables the Scansorial Birds to climb with great ease and readiness.

The most important families of the *Scansores* are the Cuckoos (*Cuculidæ*), the Woodpeckers (*Picidæ*), and the Parrots, Parrakeets, Love-birds, Lories, and Macaws (*Psittacidæ*). Many of the Cuckoos have the remarkable instinct of laying their eggs in the nests of other birds. The Parrots are almost all natives of hot climates, and the beak is hooked, and is used as a kind of third foot in climbing.

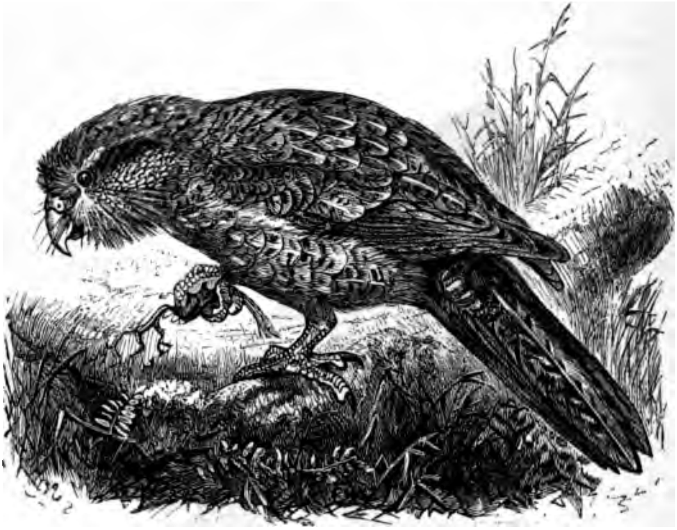


Fig. 143.—The Owl-Parrot (*Strigops habroptilus*), New Zealand.

ORDER VI. INSESSORES.—The Perching Birds are chiefly distinguished by the characters of the feet. These are chiefly adapted for building the nest and for perching on trees, and "have neither the webbed structure of those of the *Swimmers*, nor the robust strength and destructive talons which characterise the feet of the *Birds of Rapine*, nor yet the extended toes which enable the *Wader* to walk safely over marshy soils and tread lightly on the floating leaves of aquatic plants; but the toes are slender, flexible, and moderately elongated, with long, pointed, and slightly curved claws" (Owen). The feet have four toes each, three in front and one behind (fig. 144, A, B), and the form of the beak varies much in different sections of the order. The leading modifications in the shape of the bill are shown in the subjoined cut (fig. 144).

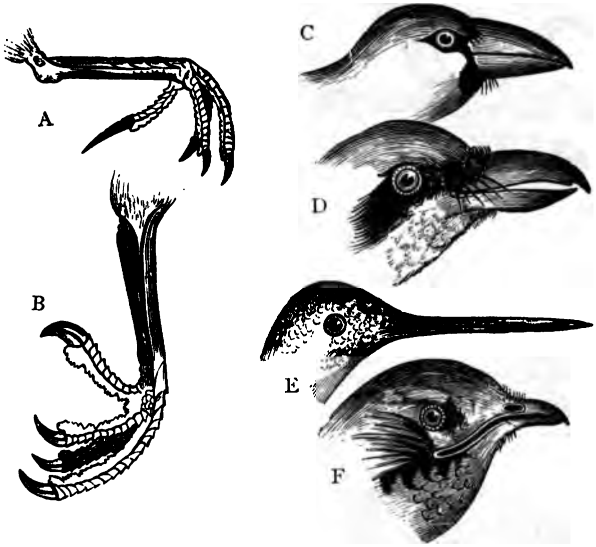


Fig. 144.—A, Foot of Yellow Wagtail; B, Foot of Water-ousel; C, Beak of Hawfinch; D, Beak of Shrike; E, Beak of Humming-bird; F, Beak of Swift.

The order *Insessores* is by far the most numerous of the divisions of Birds; and it is impossible here either to discuss the characters of its leading subdivisions, or to enter into any consideration of its typical members. As good examples of the order may be taken the Crows, Jays, and Magpies (*Corvidæ*), the Finches and Linnets (*Fringillidæ*), the Shrikes (*Laniidæ*), the Thrushes (*Merulidæ*), the Humming-birds (*Trochilidæ*), the Swallows and Martens (*Hirundinidæ*), and the Swifts (*Cypselidæ*).

ORDER VII. RAPTORES.—The Birds of Prey are characterised by the form of the beak, which is adapted for tearing animal food. The upper mandible of the bill (fig. 145, B) is "strong, curved, sharp-edged, and sharp-pointed, often armed with a lateral tooth" (Owen). The body is extremely muscular; the legs are robust, usually short, with three toes in front and one behind; all the toes armed with strong, curved, crooked claws or talons (fig. 145, A). All the Raptorial Birds

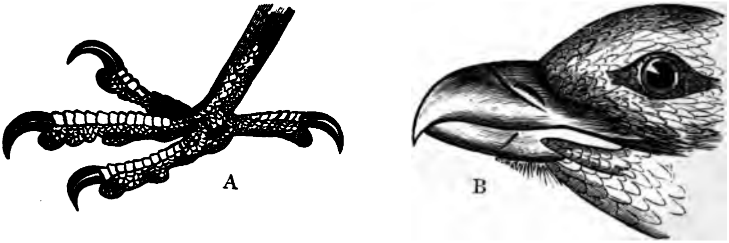


Fig. 145.—A, Foot of Peregrine Falcon; B, Head of Buzzard.

live upon the flesh of other animals, which they either kill for themselves or find dead, and their flight is generally extremely rapid and powerful.

The Birds of Prey are divided into the two sections of the Nocturnal Birds of Prey which hunt by night, and the Diurnal Birds of Prey which hunt by day. In the former section (fig. 146) is only the single family of the Owls, in which the eyes are large and are directed forwards; whilst the plumage is exceedingly soft and loose, so as to render the flight almost noiseless. In the section of the Diurnal Raptores (fig. 145) are the Falcons and Hawks, the Eagles and the Vultures. In all these the eyes are smaller than in the Owls, and are placed on the sides of the head; and the plumage is not soft. They have

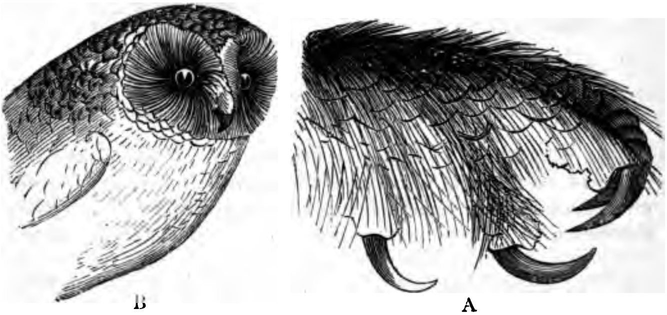


Fig. 146.—A, Foot of Tawny Owl; B, Head of White Owl.

long pointed wings, and mostly possess extraordinary powers of flight.

ORDER VIII. SAURURÆ.—Amongst fossil Birds, one, the *Archæopteryx*, deserves a passing mention, as being the type of a separate order. Only two examples of this extraordinary bird have been found, both in the lithographic slates of Solenhofen, in Bavaria. These show, however, that the tail (fig. 147) had the remarkable peculiarity of being composed of a series of separate vertebræ, each of which supports a single pair of quill-feathers. The tail was thus long, and, except for its feathers, lizard-like. The upper jaw of *Archæopteryx* carried two small conical teeth at its extremity; but the lower jaw is still unknown.

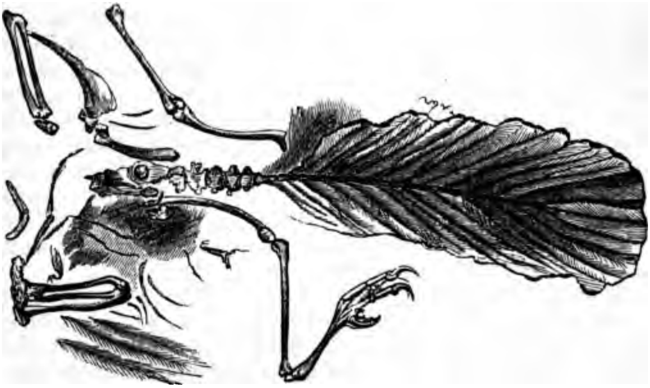


Fig. 147.—*Archæopteryx macrura*, showing tail and tail-feathers, with detached bones.

ORDERS IX. and X. ODONTOLCÆ and ODONTOTORMÆ.—In these orders are some extraordinary fossil birds from the Cretaceous rocks of North America, which have the reptilian character that they possess *teeth*, sunk in a groove in the jaw or in distinct sockets.

CHAPTER XXIII.

CLASS V. MAMMALIA.

THE class *Mammalia* includes all the ordinary Quadrupeds, and may be shortly defined as comprising Vertebrate animals, in which some part or other of the skin is always furnished with hairs, and the young are nourished for a longer or shorter time by means of a nutritive fluid—the milk—secreted by special glands belonging to the mother—the mammary glands. The Mammals are further distinguished from Birds and Reptiles by the fact that the skull is jointed to the spinal column by two joints (condyles); the lower jaw is composed of two halves, each consisting of a single piece; the red blood-corpuscles (fig. 106, *a*) are generally circular, and have no central particle or nucleus; the cavities of the chest (thorax) and belly (abdomen) are separated by a muscular partition, called the midriff or diaphragm; and the lungs never communicate with air-sacs placed in different parts of the body.

With regard to the structure of the skeleton in Mammals, it is only necessary to add to what was said in speaking of the *Vertebrata* generally, a few words as to the structure of the limbs. The regular number of limbs in the Mammals is four, two anterior and two posterior; and for this reason they are often spoken of as Quadrupeds, regardless of the fact that in some Mammals (such as the Whales and Dolphins) only the fore limbs are present. The fore and hind limbs in all Mammals have essentially the same structure as was described in treating of Vertebrates generally. The shoulder-blade or *scapula* is never absent; and the *coracoid bones*, which form such a marked feature in the shoulder-girdle of Birds, are with hardly an exception amalgamated with the scapulæ. The *clavicles* or collar-bones are often wanting or rudimentary, but in no Mammal are they ever united together in front so as to form a "furculum" or "merry-thought." The regular number of fingers or digits in the fore limb, as of toes in the hind limb, is five; but they vary from one to five, the middle finger being the longest and most persistent, and being the only finger left in the living Horses. Properly, each finger consists of three short bones or *phalanges*, except the thumb, which has two; but this rule is occasionally departed from.

The great majority of Mammals possess *teeth*, but these are wanting in the fully-grown whalebone Whales and in the Scaly and Great Ant-eaters. The teeth, also, are almost invariably implanted in distinct and separate sockets in the jaw. Some Mammals have only a single set of teeth; but in most cases the young Mammal possesses a set of what are called *milk-teeth*, which is ultimately replaced by a second set, constituting the *permanent* teeth. No Mammal has ever *more* than two sets of teeth. In Man, and in many other Mammals, the teeth are divisible into four groups, which differ from one another in position, appearance, and function, and which are termed respectively the *incisors*, *canines*, *præmolars*, and *molars*. It is impossible to describe fully which teeth come under each of these heads without entering into minute details as to the structure of the jaws. It will be sufficient here to point out the general characters and position of these groups in a good illustrative example, such as one of the higher Apes (fig. 148).

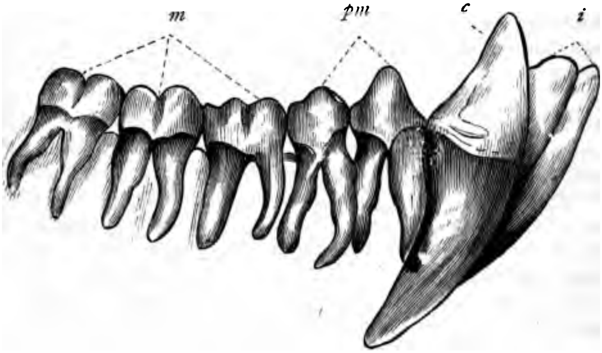


Fig. 148.—Teeth of the right side of the lower jaw of the Chimpanzee (after Owen). *i* Incisors; *c* Canine tooth; *pm* Præmolars; *m* Molars.

The *incisor* teeth (*i*) vary greatly in size and number, but they are always placed in the front of the mouth, and are the teeth which are used in simply biting or dividing the food. The *canine* or eye-tooth (*c*) is generally longer or more pointed than the other teeth. The canines are sometimes wanting, or are sometimes present in one jaw and not in the other, but there are never more than four altogether—that is to say, one on each side of each jaw. The præmolars (*pm*) and the molars (*m*) are generally known as the "back teeth" or "grinders," and they vary a good deal in number and function, being sometimes adapted for cutting the food, but more usually for chewing and grinding it down.

The skin is almost invariably furnished over a greater or less part of its surface with appendages which are known as ***hairs***, and which differ from feathers chiefly in not splitting up as they are produced. Sometimes the hairs form scales, as in the Scaly Ant-eater, and they are often developed into long spines or prickles, as in the Hedgehogs and Porcupines. In the Whales the body is almost hairless, and in the Dolphins quite so; but these latter have hairs upon the muzzle before they are born.

The young Mammal is always born in a helpless condition, and is nourished for a longer or shorter time by means of the milk of the mother. The milk is secreted by special organs called the "mammary glands," and it is from the presence of these that the name *Mammalia* is derived (Lat. ***mamma***, the breast). The number and position of the mammary glands vary in different cases, but they always are placed on the lower surface of the body, and their ducts almost always open upon a special eminence called the teat or nipple. In one or two cases, however, there are no nipples, and the mammary glands open by simple slits in the skin of the abdomen.

In the great majority of Mammals the young animal is nourished within the body of the mother by an organ which is composed of a network of blood-vessels, and is called the ***placenta*** or "after-birth." In two orders of Mammals, however, the young are born at a very early period of their existence, before there is any necessity for the formation of a placenta. From this difference the class *Mammalia* is divided into the two great divisions of the Placental and Aplacental Mammals, and these (omitting some fossil groups) contain the following fourteen orders:—

DIVISION A.—APLACENTAL MAMMALS.

Order 1.—*Monotremata.*
Order 2.—*Marsupialia.*

DIVISION B.—PLACENTAL MAMMALS.

Order 3.—*Edentata.*
Order 4.—*Sirenia.*
Order 5.—*Cetacea.*
Order 6.—*Ungulata.*
Order 7.—*Hyracoidea.*
Order 8.—*Proboscidea.*

Order 9.—*Carnivora.*
Order 10.—*Rodentia.*
Order 11.—*Cheiroptera.*
Order 12.—*Insectivora.*
Order 13.—*Quadrumana.*
Order 14.—*Bimana.*

CHAPTER XXIV.

ORDERS OF MAMMALS.

ORDER I. MONOTREMATA.—The first and lowest order of the Mammals, that of the *Monotremata,* comprises only the Duck-mole and Porcupine Ant-eater, both of which are exclusively confined to the Australian province. Irrespective of some remarkable peculiarities in their internal anatomy, the Monotremes are distinguished by having no true teeth, by possessing distinct "coracoid bones" in the shoulder-girdle, like those of Birds, and by having the so-called "marsupial bones." These last are two little bones (fig. 150, *m*) attached to the front of the bony arch (pelvic arch) by which the hind limbs are attached to the trunk. They possess, however, no "marsupial pouch," as occurs in the next order. They have, further, no external ears, and no nipples to the mammary glands, and the young are said to be destitute of a placenta.

The Duck-mole (*Ornithorhynchus*) is an extraordinary Mammal which inhabits many of the rivers and lakes of Australia. The body (fig. 149) is like that of a small otter, and is covered with a short brown fur. The tail is broad and flattened, and the jaws are sheathed with horn, so as to form a flattened beak, very like that of a duck. There are no true teeth, but the bill is furnished with small horny plates which act as teeth. The legs are short, furnished with five toes each, and webbed, so that the animal swims with great ease. Their food consists chiefly of aquatic insects and molluscs, and they make very extensive burrows in the banks of streams.

The Porcupine Ant-eater (*Echidna*) is not at all unlike a hedgehog in appearance, but larger. The skin is covered with bristly hair, with strong prickly spines on the back. The snout is very long, and there are no teeth, but the jaws are encased in skin to close upon the end of the snout, where there is a small aperture for the protrusion of a long and flexible tongue. The feet are adapted for digging and burrowing, and the animal feeds upon insects, which it captures by means of its long sticky tongue.

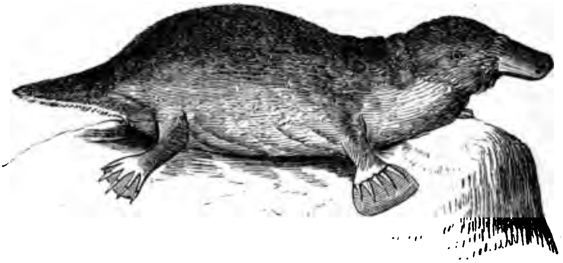


Fig. 149.—Duck-mole (*Ornithorhynchus*)—after Waterhouse.

Order II. Marsupialia. — The name *Marsupialia* is derived from the fact that the females of this order have a pouch or fold of the skin of the abdomen, which is termed the *marsupium*, and within which the nipples are placed. The young are born in a very immature and helpless condition, and are placed in this pouch by the mother, where they remain until able to take care of themselves. The so-called "marsupial bones" (fig. 150) are present, as in the *Monotremata*, but the "coracoid bones" are amalgamated with the shoulder-blades, and true teeth are always present.

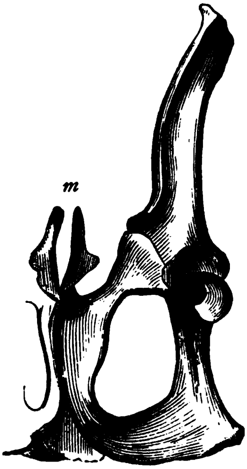


Fig. 150.—One side of the pelvis of a Kangaroo, showing the "marsupial bones" (*m*)—after Owen.

As regards their geographical distribution, with the single exception of the various Opossums (*Didelphidæ*) of America, the whole order of the Marsupials is exclusively confined to Australia, Tasmania, New Guinea, and the adjacent islands. As good examples of the Marsupials, we may take the Kangaroos, the Kangaroo-bear, and the Native Devil of Van

Diemen's Land. The Kangaroos (*Macropus*) are vegetable feeders, and are distinguished by the great disproportion between the fore and hind legs, the latter being by far the longest and strongest. By their long hind legs, assisted by a powerful tail, the Kangaroos can take astonishing jumps, and leaping is their ordinary mode of progression when pursued. The Kangaroo-bear or Koala, like the Kangaroos, is a vegetable feeder, and is a sluggish, harmless animal. By the structure of the feet it is admirably adapted for climbing amongst the trees, upon the foliage of which it feeds. It is covered with a close greyish fur, and the ears are furnished with long tufts of hair. Among the other Australian Marsupials may be mentioned the Wombat, the Bandicoots, and the Phalangers (the last known to the Australian colonists as "opossums"). The true Opossums, however, are exclusively confined to the warmer parts of North and South America. They are small animals (fig. 151), and for the most part live among trees. To this end they have the feet hand-like, and the end of the tail is prehensile or adapted for grasping. They mostly live upon small animals of different kinds. In some of the Opossums the marsupial pouch is incomplete, and then the young, shortly after birth, attach themselves by their prehensile tails to the tail of the mother, upon

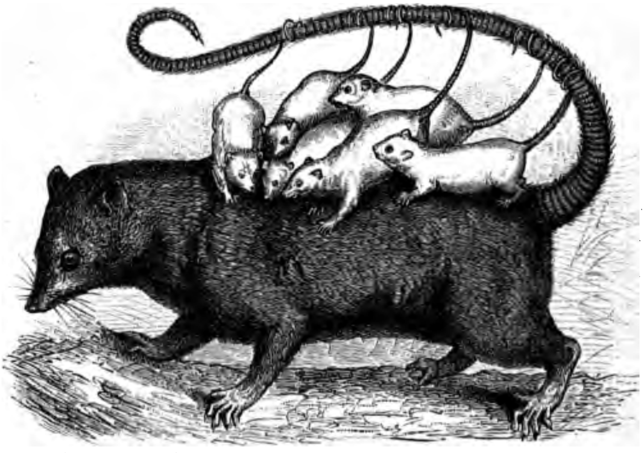


Fig. 151.—The female of *Didelphys dorsigera*, one of the South American Opossums, carrying its young upon its back.

whose back they are thus safely carried about (fig. 151). The Native Devil (*Dasyurus ursinus*) is a good example of those Marsupials which live upon animal food, or are carnivorous. It is furnished with long and strong canines, and with other teeth adapted for cutting flesh, and it is a destructive and ferocious animal. Though only as big as a small dog, it commits great havoc amongst the flocks of Van Diemen's Land, and has, in return, been to a great extent hunted down by the settlers of that island.

ORDER III. EDENTATA.—The members of this order, the Sloths, Armadillos, and Ant-eaters, are characterised by the fact that the teeth are not covered by enamel, have no complete roots, and are not succeeded by a second set. In none are there any central incisors, and in all but one there are no incisors at all. In two genera there are no teeth at all, and to these the name *Edentata* would be strictly applicable. In all, the toes are furnished with long and powerful claws.

The Sloths (*Bradypodidæ*) are exclusively confined to South America, inhabiting the vast and trackless forests of this continent. They are admirably adapted for their mode of life, which necessitates their living almost exclusively amongst and upon the trees, on the leaves of which they feed. They are, however, extremely awkward upon the ground, as their long curved claws are intended to allow them to move about, back downwards, amongst the branches of trees.

The Armadillos (*Dasypodidæ*) are also exclusively confined to South America, but they are carnivorous burrowing animals, and are furnished with strong digging claws. The upper surface of the body is protected by a kind of armour formed of hard bony plates or shields united at their edges. Most of them can roll themselves into a ball, like the Hedgehog, and they can all bury themselves in the ground if pursued.

Besides the Sloths and Armadillos, South America can boast of possessing the hairy Ant-eaters, of which the best known is the Great Ant-eater (*Myrmecophaga jubata*). The body in this curious animal is hairy, with a long bushy tail; and teeth are wholly absent. It lives upon insects, which it catches by rapidly protruding and retracting its long and sticky tongue.

The Old World possesses only two genera of *Edentata*, comprising the scaly Ant-eaters (*Manis*) of Asia and Africa, and the Ground Hog (*Orycteropus*) of South Africa. The scaly Ant-eaters or Pangolins (fig. 152) are remarkable for having the body covered with a flexible armour composed of horny plates or scales, overlapping like the tiles of a house. Like the South American Ant-eaters also, the Pangolins are entirely without teeth, and live upon insects which they catch with their long sticky tongues.

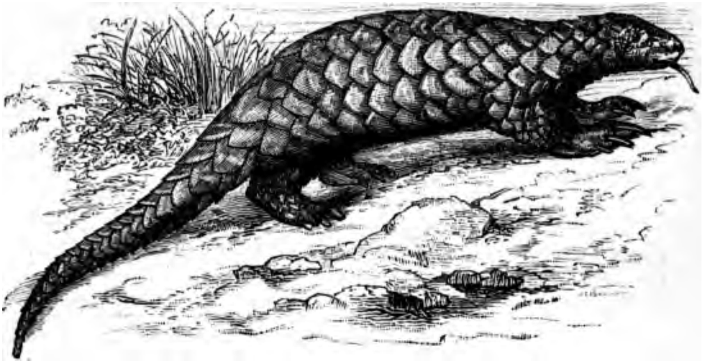


Fig. 152.—*Manis pentadactyla*, one of the scaly Ant-eaters or Pangolins, showing the armour of horny plates.

ORDER IV. SIRENIA.—This order comprises only the great sea-animals known as Dugongs and Manatees. They were long classed with the Whales and Dolphins, and agree with them in being adapted to a thoroughly aquatic life, having no hind limbs, but having the fore limbs converted into swimming-paddles, whilst the hinder end of the body (fig. 153) forms a powerful horizontal tail-fin. They differ from the Whales and Dolphins in having the nostrils placed at the front of the head, and in having molar teeth with flat crowns adapted for a vegetable diet.

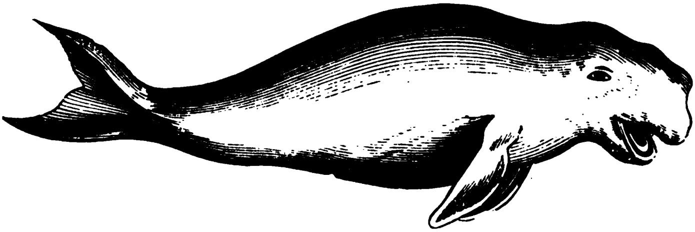


Fig. 153.—The Dugong (*Halicore Indicus*).

The Manatees, or, as they are often called, "Sea-cows," are found on the east coast of America and the west coast of Africa, and are large awkward animals, attaining a length of from eight to ten or fifteen feet. They are vegetable-eaters, feeding chiefly upon sea-weeds, and haunting the mouths of rivers and estuaries. The Dugongs (fig. 153) differ little in appearance and habits from the Manatees, and are found on the coasts of the Indian Ocean and the north coast of Australia. They attain a length of from eighteen to twenty feet, and are often killed and eaten.

ORDER V. CETACEA.—This order includes the Whales, Dolphins, and Porpoises, and agrees with the *Sirenia* in the fact that its members are adapted to a completely aquatic life. The body is fish-like in form (fig. 154) the hind limbs are wanting, and the fore limbs are converted into swimming-paddles or "flippers," whilst the hinder end of the body forms a very powerful horizontal tail-fin. The nostrils form a single or double aperture, which is placed on the top of the head and is known as the "blow-hole." The body is very sparingly furnished with hairs, or is quite hairless. The head is disproportionately large, and the adult has either no teeth at all or possesses a single set of conical teeth not separable into distinct groups. They are all carnivorous or live upon animal food.

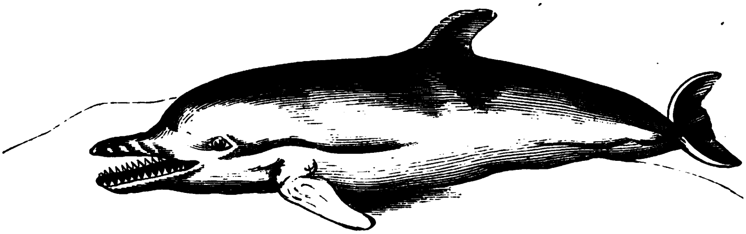


Fig. 154.—The common Dolphin (*Delphinus delphis*).

The most important of the *Cetacea* are the whalebone Whales (*Balænidæ*), in which the adult has no teeth, but the palate is furnished with a number of transverse plates of whalebone or *baleen*. These baleen-plates have their edges furnished with numerous fibres of whalebone, and the whole apparatus is used as a kind of sieve or filter to separate from the sea-water the minute marine animals upon which these enormous creatures feed. The best known and most valuable of the whalebone

Whales is the Greenland Whale, which yields most of the whale-oil and whalebone of commerce. It is a native of the Arctic seas, and attains a length of from forty to sixty feet. The oil is derived from a thick layer of fat or "blubber," which is situated immediately under the skin. The discovery of a whale is usually made by means of what is called the "spouting" or "blowing" of the animal. This consists in the forcible ejection from the blow-hole of a column or jet of watery vapour, mixed with water, which is visible for a considerable distance.

The Toothed Whales are best known by the Sperm Whale, an animal as large as, or larger than, the Greenland Whale, but distinguished by having numerous conical teeth in the lower jaw, a single blow-hole, and a curiously truncated head. The Sperm Whales yield an excellent oil, and also the singular fatty substance known as spermaceti.

The Dolphins and Porpoises form the last family of the *Cetacea*, and are distinguished by their single blow-hole and numerous conical teeth. They are inhabitants of the sea, but three species of Dolphin live in rivers—one in America, and the other two in India. One of the most remarkable of this group is the Narwhal or Sea-unicorn, which inhabits the Arctic seas. In this singular animal one of the canine teeth of the males is enormously developed, and constitutes a great tusk or pole of ivory, eight or ten feet in length, and having its whole surface spirally twisted.

ORDER VI. UNGULATA.—This order comprises the so-called Hoofed Quadrupeds, and is characterised by having all the four limbs, and by having that portion of the toe which touches the ground encased in a greatly expanded nail or *hoof*. There are never more than four full-sized toes to each foot, and the legs are only used in locomotion and in supporting the weight of the body. There are always two sets of teeth, and the molars have broad crowns adapted for grinding vegetable substances.

The *Ungulates* are divided into two great sections, according as the toes are even or odd in number:—

A. Perissodactyla, or Odd-toed Ungulates, in which the toes are odd in number—either one or three; and if horns are present they are not in pairs.

B. Artiodactyla, or Even-toed Ungulates, in which the toes are even in number—either two or four; and if horns are present they are in pairs.

The living Perissodactyle or Odd-toed Ungulates are the

Rhinoceros, the Tapirs, and the Horse and its allies. The Rhinoceroses are extremely large and bulky brutes, having a thick and nearly hairless skin, usually thrown into deep folds. The feet (fig. 155, B) are furnished with three toes each, all encased in hoofs. The nose is furnished with one or two horns composed of longitudinal fibres, and without any central core or bone. When two horns are present (fig. 156) they are not *paired*, but one is always placed behind the other in the middle line of the body, and the hinder one is much the shorter. The various species of Rhinoceros are found in Java, Sumatra,

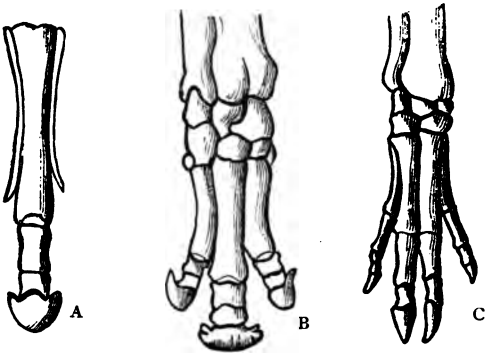


Fig. 155.—Feet of *Ungulata.* A, Odd-toed foot of Horse; B, Odd-toed foot of Rhinoceros; C, Even-toed foot of Pig.

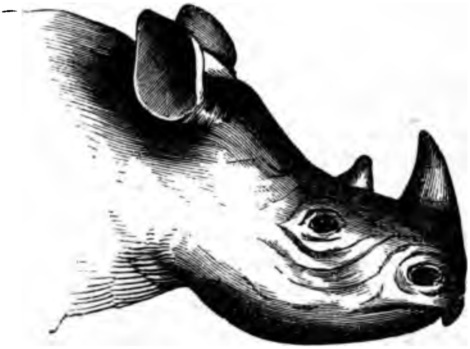


Fig. 156.—Head of two-horned Rhinoceros.

India, and Africa, inhabiting marshy places, and feeding chiefly upon the foliage of trees.

The *Tapirs* are large clumsy animals, which inhabit South America, Sumatra, and Malacca. They have the nose prolonged into a short movable proboscis or trunk, which they employ in stripping off the leaves of trees.

The last family of the Perissodactyle Ungulates is that of the *Equidæ*, comprising the Horse, Ass, Zebra, and Quagga. In the living forms the toes are reduced to *one* to each foot, enclosed in a single broad hoof, without any supplementary hoofs (fig. 155, A). At the present day all the members of the family *Equidæ* are natives of the Old World, but fossil horses occur in both North and South America, and the horse has now become completely naturalised in the New World.

The *Artiodactyla*, or Even-toed Ungulates, are divided into two groups :—

1. *Omnivora*, as the Pig and Hippopotamus.
2. *Ruminantia*, which chew the cud, such as an Oxen, Deer, Camels, &c.

Of the *Omnivorous* forms, the Hippopotamus is characterised by its massive heavy body, short blunt muzzle, and feet with four hoofed toes each. The Hippopotamus is found in Africa, and reaches a length of eleven to twelve feet. It is nocturnal in its habits, and swims and dives with great facility. A small species is found on the west coast of Africa. The Pigs, Peccaries, and Wart-hogs have usually four toes to each foot, but only two support the weight of the body, the remaining toes being placed at some elevation on the back of the foot. They have a short movable snout, and the tail is very short, or is represented by a mere tubercle.

The *Ruminants* are distinguished by their "cloven" feet, each consisting of two symmetrical hoofed toes, looking as if produced by the splitting into two of a single hoof. Often there are also two small supplementary toes placed on the back of the foot. As a general rule, the Ruminants have neither canine nor incisor teeth in the upper jaw, and the lower incisors bite against a hardened pad of gum. There are six præmolar and molar teeth on each side of each jaw, and these have grinding surfaces. The stomach is divided into several compartments, and all the Ruminants "chew the cud" or "ruminate" —that is to say, they first swallow their food unmasticated, and then bring it up again after a longer or shorter period in order to chew it.

The most important families of the *Ruminantia* are the

Camels and Llamas (*Camelidæ*), the true Deer (*Cervidæ*), the Giraffes, and the Oxen, Sheep, Goats, and Antelopes (*Cavicornia*).

The Camels and Llamas have no horns—and the feet have two toes, each covered by an imperfect nail-like hoof. The true Camels are exclusively confined to the Old World, and their place is taken in South America by the Llama and Alpaca.

The family *Cervidæ* includes the true Deer, and is characterised by the fact that the forehead carries two solid bony "antlers" (fig. 157), which are not hollow, and are generally much branched. With the single exception of the Reindeer, these appendages, are confined to the males, and they are annually produced and annually shed, increasing in size and in the number of branches every time they are reproduced. They must be carefully distinguished from the *hollow* horns of Antelopes, Oxen, Sheep, and the like.

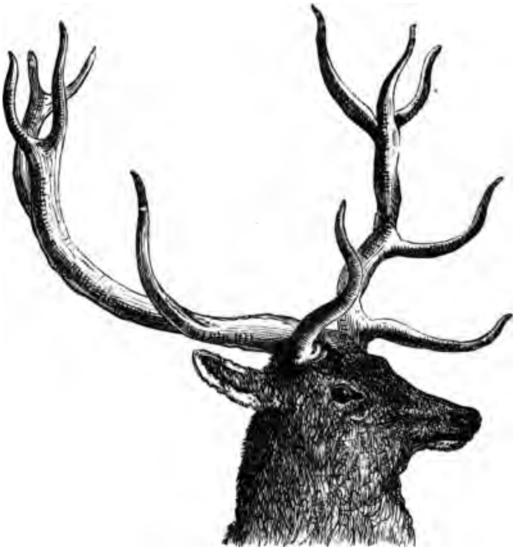


Fig. 157.—Head of Stag (*Cervus elaphus*).

The Giraffe is exclusively confined to the African continent, and only a single species is known. Both sexes have a pair of short horns, but these are persistent, and are covered with a hairy skin. The neck is extremely long, and the fore legs longer than the hind legs. It is the largest of living Ruminants, and attains a height of from fifteen to eighteen feet.

The *Cavicornia*, or *Hollow-horned* Ruminants, are characterised by having *hollow* horns, consisting of an outer sheath of horn surrounding a central bony stem or "horn-core" (fig. 158).

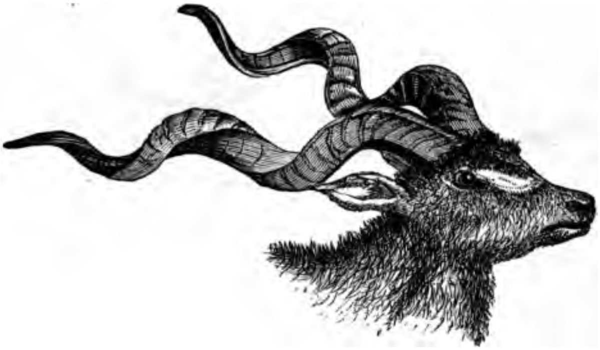


Fig. 158.—Head of an Antelope, the Koodoo (*Strepsiceros Koodoo*).

The horns are persistent and are not periodically shed (except in one Antelope, which annually sheds the sheath of the horns), and there is usually only a single pair, though sometimes there are two pairs. The group of the *Cavicornia* comprises the Oxen, Sheep, Goats, and Antelopes, and may be regarded as the most typical section of the Ruminants.

ORDER VII. HYRACOIDEA.—This order merely requires to be mentioned, as it includes only a single genus (*Hyrax*), of which no more than two or three species are known. They are all gregarious little animals, living in holes of the rocks, or amongst trees, and capable of domestication. One species occurs in South Africa, and is known to the Dutch colonists as the "Badger." Another species occurs in the rocky parts of Arabia and Palestine, and is believed to be the animal referred to in Scripture as the "Coney."

ORDER VIII. PROBOSCIDEA.—This order is represented at the present day by the Elephants only, of which no more than two species are known. One of these is the African Elephant, distinguished by its convex forehead and great flapping ears; the other is the Indian Elephant, which has a concave forehead and small ears. The name *Proboscidea* is derived from the fact that the nose is prolonged into a long cylindrical trunk or *proboscis* (fig. 159, *n*), at the extremity of which the nostrils are placed. There are no canine teeth, nor lower incisors, and the molar teeth are few in number and of large size. The upper incisors, however, are two in number, continue growing during the life of the animal, and constitute the well-known "tusks" of the Elephant (fig. 159, *i*). The feet are furnished with five toes each, but these are only partially indicated externally by being provided with hoofs; and the animal walks upon thick pads of integument which constitute the soles of the feet.

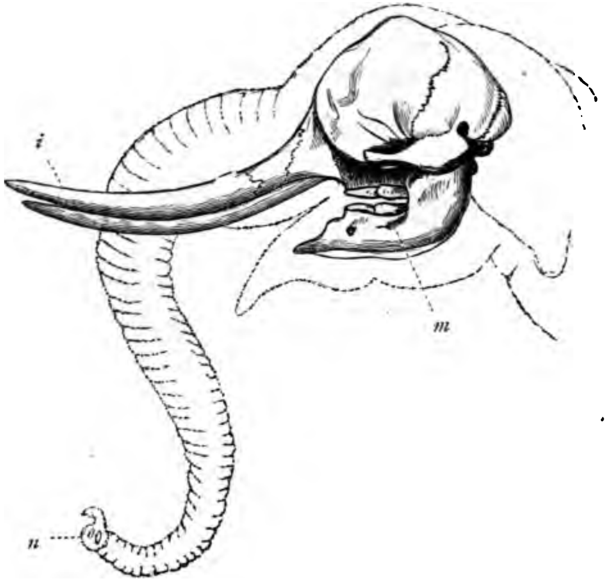


Fig. 159.—Skull of the Indian Elephant. *i* Tusk-like upper incisors; *m* Lower jaw, with grinding molars, but without incisors; *n* Nostrils, placed at the extremity of the proboscis.

Though only two living Elephants are known, many fossil forms have been detected; and one of these, the Mammoth, is known to have survived into the human period.

ORDER IX. CARNIVORA. — The Carnivorous Mammals or Beasts of Prey are chiefly distinguished by the adaptation of their teeth to an animal diet. The incisor teeth are generally six in each jaw; the canines are two in each jaw, and are always long and pointed. The molars and præmolars are mostly furnished with sharp cutting edges, adapted for dividing flesh; but one, or more, of the hinder molars is generally furnished with a simply tuberculate crown, adapted for bruising rather than cutting. The feet in the *Carnivora* are always furnished with strong curved claws, and the collar bones are quite rudimentary, or are altogether wanting. The *Carnivora* are divided into the following three sections, founded upon the nature of the limbs :—

1. *Pinnigrada* (fig. 160, B) *in which both the fore and hind legs are short, and the feet form broad webbed swimming-paddles. The hind feet are placed very far back, nearly in a line with the axis of the body.* This section comprises the Seals and Walruses, characterised by their adaptation to an aquatic mode of life. They are, however, at once distinguished from the *Sirenia* and *Cetacea* by possessing well-developed *hind limbs.* The Seals (fig. 161) form a very numerous family, of which species are found in most seas out of the tropics. They are largely captured both for their oil and fur; and the subjoined cut will give an idea of most of their external peculiarities.

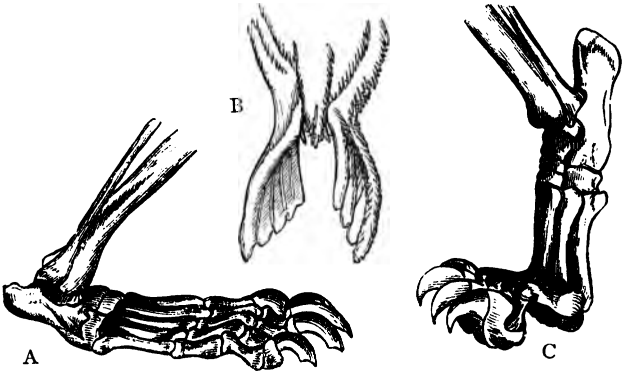


Fig. 160.—Feet of *Carnivora* (after Owen). A, *Plantigrada;* Foot of Bear. B, *Pinnigrada;* Hind feet of Seal. C, *Digitigrada;* Foot of Lion.

The Walrus or Morse is like the Seals in most respects, but the upper canine teeth are developed into two large pointed tusks. It is a large heavy animal which is found in flocks in the Arctic seas, and is hunted both for its blubber and for the ivory of its tusks.

2. *Plantigrada* (fig. 160, A), *in which the whole or nearly the whole of the foot is applied to the ground, so that the animal walks upon the soles of the feet.* The most characteristic members of this order are the Bears (*Ursidæ*), of which the common Brown Bear and the White or Polar Bear are familiar examples. The bears eat flesh when they can get it, but they are very miscellaneous in their diet, and their teeth do not, therefore, exhibit the typical carnivorous characters, the præmolars and molars having broad tuberculate crowns. The claws are large, curved, and strong, but are not retractile, and the tongue is smooth.

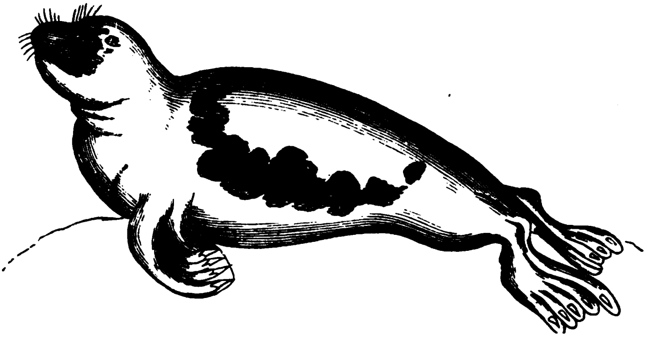


Fig. 161.—Greenland Seal (*Phoca Grœnlandica*).

3. *Digitigrada* (fig. 160, C), *in which the heel is raised from the ground, and the animal walks upon tiptoe.* The most typical members of this section are the Dogs (*Canidæ*), the Hyænas (*Hyænidæ*), and the Cats (*Felidæ*). Besides the true Dogs, the family *Canidæ* comprises the Wolves, Foxes, and Jackals. The Hyænas are ferocious, ill-conditioned animals, which occur in Africa, Asia Minor, Arabia, and Persia. The group of the *Felidæ*, besides the true Cats, comprises a number of the fiercest and most typical members of the whole order *Carnivora*, such as the Lion, Tiger, Leopard, Jaguar, Puma, and Lynx. They are all characterised by the completely carnivorous form of their teeth, the possession of strong curved claws which can be withdrawn within sheaths by the action of elastic ligaments, and by the fact that the tongue is rough and prickly.

ORDER X. RODENTIA.—In this order are a number of small animals, characterised by having no canine teeth, but by having two long curved incisors in each jaw, separated by an interval from the molars (fig. 162, A). Sometimes there are four incisors in the upper jaw, but there are never more than two in the

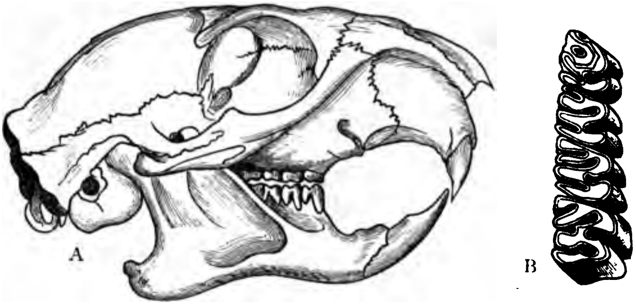


Fig. 162.—A, Side-view of the skull of *Sciurus* (*Cynomys*) *Ludovicianus;* B, Molar teeth of the upper jaw of the Beaver (*Castor fiber*). (After Giebel.)

lower. Each incisor (fig. 162, A) is long and curved, and continues growing during the life of the animal. The front of the tooth is covered with a layer of hard enamel, and the softer parts of the tooth are placed behind. The result of this is, that as the tooth is used in gnawing, the softer parts of the tooth behind wear away more rapidly than the hard enamel in front, and thus the crown of the tooth assumes by use a chisel-shaped point, which has a sharp cutting edge formed by the enamel. From this structure of the incisors, the Rodents are adapted for rapid and continuous gnawing, and they live chiefly upon the harder parts of plants, such as the bark and roots.

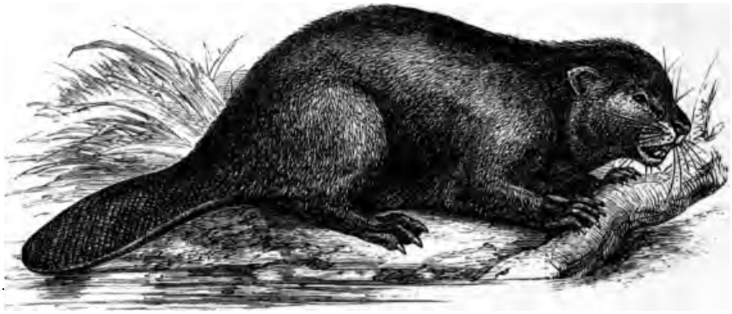


Fig. 163.—The Beaver (*Castor fiber*).

The Rodents are almost all of small size, and are very generally distributed over the whole world. The most important families included in the order are the Hares and Rabbits (*Leporidæ*), the Capybaras and Guinea-pigs (*Cavidæ*), the Beavers (*Castoridæ*, fig. 163), the Rats and Mice (*Muridæ*), the Porcupines (*Hystricidæ*), the Dormice (*Myoxidæ*), and the Squirrels and Marmots (*Sciuridæ*).

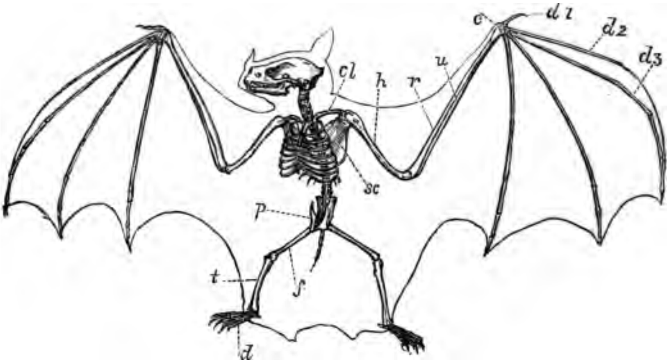


Fig. 164.—Skeleton and outline of Bat (*Phyllostoma hastatum*). *d1* Thumb; *d2* Fore-finger; *d3* Middle finger; *sc* Shoulder-blade; *cl* collar-bone; *f* Thigh-bone; *t* Tibia; *d* Toes.

ORDER XI. CHEIROPTERA.—This order comprises only the Bats or Flying Mammals, characterised by the fact that the fore limbs are much longer than the hind limbs, and have several of the fingers greatly lengthened. These immensely lengthened fingers are united by an expanded leathery membrane, which not only stretches between the fingers, but is also extended between the fore and hind limbs, and is attached to the sides of the body (fig. 165). The flying-membrane often stretches between the hind legs and includes the tail, and it is nearly or quite hairless. By means of this flying-membrane the Bats enjoy the power of true flight, and they are the only Mammals which do so, though their flight is by no means so rapid and active as in the true Birds.

The Bats are all twilight-loving or nocturnal animals, and are divided into two sections, according as they live upon insects or feed chiefly upon fruits. In the first section are all our British Bats. In the second section are the so-called Fox-bats (*Pteropidæ*), which are especially characteristic of the

Pacific Archipelago, and sometimes attain a very large size, one species having a stretch of wing of from four to five feet.

ORDER XII. INSECTIVORA.—This order includes a number of small animals, which in many respects are very like the Rodents, but have not the peculiar incisor teeth of that order. All the three kinds of teeth are present, and the molar teeth are distinguished by having small pointed eminences or "cusps," adapted for crushing insects. Collar-bones are always present, and most of the *Insectivora* are *plantigrade*—that is to say, they walk upon the soles of the feet. They are all of small size, and they exist over the whole world, except in Australia and South America, where their place is taken by small Marsupials, such as the Opossums.

The three most important families of the *Insectivora* are the Moles (*Talpidæ*), the Shrews (*Soricidæ*), and the Hedgehogs (*Erinaceidæ*). The Moles (fig. 165) are all nocturnal burrowing animals, and the feet have strong curved digging-claws. The eyes are very small or completely rudimentary in the adult, and sight must be often almost or altogether wanting. The Shrews are very like the true Mice in external appearance, but are really widely different. They are very widely distributed, and one of them is probably the smallest of existing Mammals. The Hedgehogs must be very familiar to every one, as having the upper surface of the body covered with short prickly spines, and by having the power of rolling themselves up into a ball on the approach of danger.

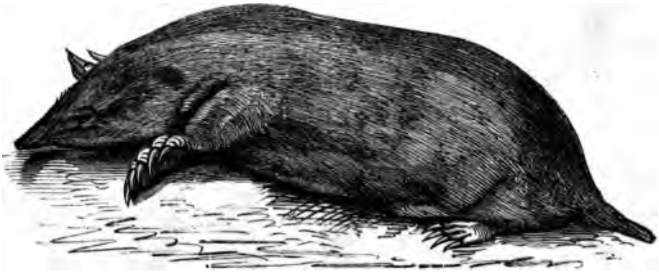


Fig. 165.—The Mole (*Talpa Europæa*).

ORDER XIII. QUADRUMANA.—This order includes the Apes, Monkeys, Baboons, and Lemurs, and is characterised by the fact that the innermost toe of the hind limb (great toe) can be *opposed* to the other toes, so that the hind feet become prehensile hands. The term "opposed" simply implies that the toe can be so adjusted as regards the extremities of the other toes that any object can be grasped between them, just as the thumb of the human hand can be "opposed" to the other fingers. The fore feet of the *Quadrumana* may be destitute of a thumb, but when this is present it is generally opposable to the other digits, so that the animal becomes truly four-handed or "quadrumanous."

The most important group of the lower *Quadrumana* is that of the Lemurs, comprising a number of small cat-like animals, with a close soft fur and long hairy tails. The true Lemurs are often called "Madagascar Cats," and are exclusively confined to the large forests of that island, moving about amongst the trees with great activity by means of their prehensile tails. The South American Monkeys, such as the Marmosets, Howlers, and Spider-monkeys, live amongst the great forests of that continent, and are mostly adapted for climbing about amongst trees. Their tails are therefore generally prehensile, and the thumbs of the fore feet are either wanting or are not opposable to the other fingers.

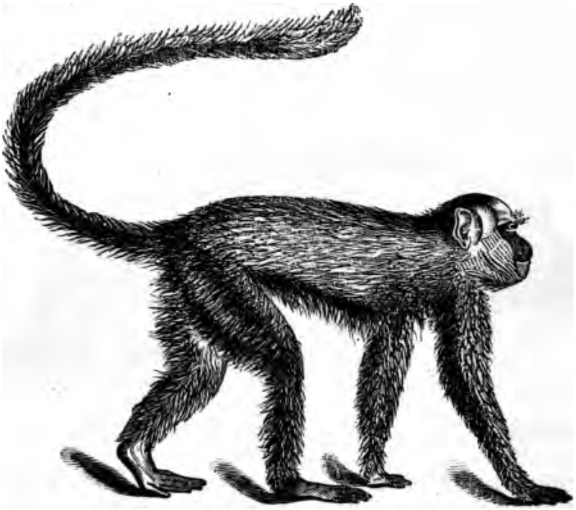


Fig. 166.—Green Monkey (*Cercocebus sabæus*)—after Cuvier.

The highest Apes are those which inhabit the Old World, and they are distinguished by never having a prehensile tail, whilst the thumbs of the fore feet are opposable. Amongst these are the *Macaques* and *Semnopitheci* of Asia, and the hideous Baboons. The Baboons form a well-marked group of the *Quadrumana*, and are amongst the most repulsive members of the whole order. They are mainly African, and are distinguished by their long dog-like muzzles, their short rudimentary tail, and the great extent to which they employ the fore limbs in terrestrial progression. The highest of the Old World Apes are often called *Anthropoid*, from their making a closer approach to man in anatomical structure than is the case with any other Mammal. The Anthropoid Apes have neither tails nor cheek-pouches, and the best known members of the group are the Orang-outang, the Chimpanzee, and the Gorilla. All these Apes mimic man more or less closely in appearance and structure, but much more closely when young than when grown up. The Orang-outang inhabits Sumatra, Borneo, and the other larger islands of the Indian Archipelago. The Chimpanzee inhabits Western Africa, and the Gorilla inhabits Lower Guinea and Equatorial Africa. The latter attains a height of fully five feet, and is enormously strong and ferocious.

ORDER XIV. BIMANA.—In this order stands Man alone, and little need therefore to be said on this head. Man is distinguished *zoologically* from all other Mammals by his habitually erect posture and progression upon two legs. The lower limbs are exclusively devoted to progression and to supporting the weight of the body. The fore limbs are shorter than the legs, and have nothing to do with progression. The thumb can be opposed to the other digits, and the hands are therefore prehensile. The fingers and toes are furnished with nails; but the great toe is not capable of being opposed to the other toes, so that the foot is useless as an organ of grasping. The foot is broad and plantigrade, the whole sole being applied to the ground in walking. The teeth form a nearly even and uninterrupted series, without any gap or interval. The brain is more largely developed and more richly furnished with large and deep foldings than is the case with any other Mammal. Lastly, Man is the only terrestrial Mammal in which the body is not furnished with a general covering of hair.

We thus see that the purely *anatomical* distinctions between Man and the other Mammals are by no means so striking as might have been anticipated; but this should lead us to perceive that Man's place in nature is to be settled not by his anatomical structure, but by the perfection of his mental and moral attributes.

TABULAR VIEW OF THE CHIEF SUBDIVISIONS OF THE ANIMAL KINGDOM.

SUB-KINGDOM I.—PROTOZOA.

Animal simple or compound, usually very minute; the body composed of a jelly-like albuminous substance called "protoplasm" or "sarcode," not divided into regular segments; no nervous system; no definite body-cavity. Digestive and circulatory systems absent or rudimentary.

CLASS A. GREGARINIDÆ.—Protozoa which live parasitically in the interior of insects and other animals, which are destitute of a mouth, and have no power of throwing out prolongations or processes of the body-substance ("pseudopodia").

CLASS B. RHIZOPODA (Root-footed Protozoa).—Protozoa which are simple or compound, and have the power of throwing out and retracting temporary prolongations of the body-substance ("pseudopodia"). A mouth generally, if not universally, absent. *Ex.* Sponges, Amœba.

CLASS C. INFUSORIA (Infusorian Animalcules).—Protozoa mostly with a mouth and short gullet; destitute of the power of emitting pseudopodia; furnished with vibrating hair-like processes (cilia) or contractile filaments; the body composed of three distinct layers. *Ex.* Bell-animalcule.

SUB-KINGDOM II.—CŒLENTERATA.

Animals whose alimentary canal communicates freely with the general space included within the walls of the body, so that the "body-cavity" comes to communicate with the outer medium through the mouth. Body composed of two fundamental layers or membranes, an outer layer and an inner layer. No central organ of the circulation or distinct blood-system; in most no anatomically recognisable nervous system. Skin furnished with microscopic stinging organs or "thread-cells." Reproductive organs in all, but multiplication often by non-sexual methods.

CLASS A. HYDROZOA.—Walls of the digestive sac not separated from those of the general body-cavity, the two coinciding with one another. Reproductive organs external. *Ex.* Fresh-water Polypes (*Hydra*); Sea-firs (*Sertularia*); Pipe-corallines (*Tubularia*); Jelly-fishes (*Medusæ*); Portuguese Man-of-war (*Physalia*); Sea-blubbers (*Aurelia*); Hydro-corallines (*Millepora*); Graptolites.

CLASS B. ACTINOZOA.—Stomach distinct, opening below into the body-cavity, which is divided into a number of compartments by vertical partitions or "mesenteries." Reproductive organs internal. *Ex.*

Sea-anemones (*Actinia*); Star-corals (*Zoantharia*); Sea-pens, Sea-shrubs, Red-coral (*Alyconaria*); Venus's Girdle (*Cestum*).

SUB-KINGDOM III.—ECHINODERMATA.

Marine animals in which an alimentary canal is always present, and is always completely shut off from the general cavity of the body. There exists a peculiar system of canals distributed through the body, filled with a watery fluid, and known as the "water-vascular" system. The vessels of this system are usually placed in direct communication with the exterior, and from their being generally employed in locomotion are termed "ambulacral vessels." Integument composed of numerous calcareous plates jointed together, or leathery, and having grains, spines, or tubercles of calcareous matter deposited in it. Nervous system radiate. Adult generally more or less star-like or "radiate" in shape; young usually showing more or less distinct "bilateral symmetry"—that is, showing similar parts on the two sides of the body.

Order 1. *Crinoidea* (Sea-lilies and Feather-stars).
Order 2. *Ophiuroidea* (Sand-stars and Brittle-stars).
Order 3. *Asteroidea* (Star-fishes).
Order 4. *Echinoidea* (Sea-urchins and Sea-eggs).
Order 5. *Holothuroidea* (Sea-cucumbers).

SUB-KINGDOM IV.—ANNULOSA.

Animals possessing a body which is commonly elongated, often worm-like, and never "radiate" in form. Very generally, the body is divided into a greater or less number of distinct rings or segments, which are placed one behind the other. If locomotive appendages are present, they are carried on the sides of the rings, and are, therefore, "bilaterally symmetrical." A distinct nervous system is present, but varies in form, its position being in the anterior or ventral region of the body.

DIVISION I. SCOLECIDA.—Body not divided into regular rings or segments, though often worm-like in form. A system of "water-vessels" present, but not concerned in locomotion. No true blood-system. Nervous system of one or two ganglia placed in the front part of the body, and not disposed in a radiate manner. Lateral appendages almost invariably wanting. Animal often parasitic.

Order 1. *Tæniada* (Tape-worms).
Order 2. *Trematoda* (Flukes).
Order 3. *Turbellaria* (Planarians).
Order 4. *Acanthocephala* (Thorn-headed Worms).
Order 5. *Gordiacea* (Hair-worms).
Order 6. *Trematoda* (Round-worms).
Order 7. *Rotifera* (Wheel-animalcules).

DIVISION II. ANARTHROPODA.—Body worm-like, composed of numerous similar or nearly similar rings. Bilaterally placed appendages usually present, but never distinctly jointed or articulated to the body. No true blood-vessels, but a system of branching "pseudo-hæmal" vessels, which take the place of such. Nervous system ventrally placed, and typically consisting of a double chain of ganglia, united by longitudinal cords, and forming a collar round the gullet.

Class A. Gephyrea.—Body cylindrical, not definitely segmented. Mouth usually with a circlet of tentacles. Ventral cord of the nervous system not furnished with ganglia. *Ex.* Spoonworms.

Class B. Annelida.—Body cylindrical, definitely segmented. A special system of vessels connected with respiration ("pseudo-hæmal" vessels). A gangliated ventral nerve-chain.

Order 1. *Hirudinea.*—*Ex.* Leeches (Hirudo).
Order 2. *Oligochæta.*—*Ex.* Earth-worms (Lumbricus).
Order 3. *Tubicola.*—*Ex.* Tube-worms (Serpula).
Order 4. *Errantia.*—*Ex.* Sand-worms (Nereis).

Class C.—Chætognatha.—*Ex.* Sagitta.

Division III. Arthropoda.—Annulose animals in which the body is composed of a generally definite series of distinct rings or segments. Integument usually greatly hardened by horny matter, with or without a certain amount of lime-salts. Locomotive bilaterally disposed appendages usually present, and always distinctly jointed or articulated to the body. Generally a true blood-system present, the heart being placed towards the back of the animal. Nervous system typically in the form of a double chain of nervous masses, a pair of ganglia being primitively developed in each segment, and the front pair of ganglia being placed above the gullet.

Class A. Crustacea.—Respiration aquatic, by the general surface of the body, or by gills. Two pairs of antennæ. Locomotive appendages more than four pairs in number, carried upon the thorax, and mostly upon the abdomen also.

Order 1. *Ichthyophthira.*—*Ex.* Lernæa (Fish-lice).
Order 2. *Cirripedia.*—*Ex.* Acorn-shells (Balanus), Barnacles (Lepas).
Order 3. *Ostracoda.*—*Ex.* Cypris, }
Order 4. *Copepoda.*—*Ex.* Cyclops, } Water-fleas.
Order 5. *Cladocera.*—*Ex.* Daphnia, }
Order 6. *Phyllopoda.*—*Ex.* Apus.
Order 7. *Trilobita.*—*Ex.* Angelina.
Order 8. *Merostomata.*—*Ex.* King-crabs (Limulus), Eurypterida.
Order 9. *Læmodipoda.*—*Ex.* Whale-louse (Cyamus).
Order 10. *Isopoda.*—*Ex.* Wood-lice (Oniscus).
Order 11. *Amphipoda.*—*Ex.* Sand-hopper (Talitrus).
Order 12. *Stomapoda.*—*Ex.* Locust-shrimp (Squilla).
Order 13. *Decapoda.*—*Ex.* Lobsters (Homarus), Hermit-crabs (Pagurus), Crabs (Cancer).

CLASS B. ARACHNIDA.—Respiration aerial, by the surface of the body, by pulmonary chambers, or by air-tubes ("tracheæ"). Antennæ, one pair only, converted into jaws. Head and thorax amalgamated. Four pairs of legs. Abdomen destitute of limbs.

Order 1. *Podosomata.*—*Ex.* Sea-spiders (Pycnogonum).
Order 2. *Monomerosomata.*—*Ex.* Mites (Acarida).
Order 3. *Adelarthrosomata.*—*Ex.* Harvest-spiders.
Order 4. *Pedipalpi.*—*Ex.* Scorpions (Scorpio).
Order 5. *Araneida.*—*Ex.* House-spiders (Tegenaria).

CLASS C. MYRIAPODA.—Respiration aerial, by air-tubes ("tracheæ"), or by the skin. Head distinct; remainder of the body composed of nearly similar segments. Legs more than eight pairs in number, borne partly by the abdomen. One pair of antennæ.

Order 1. *Chilopoda.*—*Ex.* Centipedes (Scolopendra).
Order 2. *Chilognatha.*—*Ex.* Millepedes (Iulus).
Order 3. *Pauropoda.*—*Ex.* Pauropus.
Order 4. *Onychopoda.*—*Ex.* Peripatus.

CLASS D. INSECTA.—Respiration aerial, by air-tubes ("tracheæ"). Head, thorax, and abdomen distinct. One pair of antennæ. Three pairs of legs borne on the thorax. No locomotive limbs on the segments of the abdomen.

Order 1. *Anoplura.*—*Ex.* Lice (Pediculus).
Order 2. *Mallophaga.*—*Ex.* Bird-lice.
Order 3. *Collembola.*—*Ex.* Spring-tails (Podura).
Order 4. *Thysanura.*—*Ex.* Lepisma.
Order 5. *Hemiptera.*—*Ex.* Plant-lice (Aphides).
Order 6. *Orthoptera.*—*Ex.* Cockroaches (Blattina).
Order 7. *Neuroptera.*—*Ex.* Dragon-flies (Libellulidæ).
Order 8. *Aphaniptera.*—*Ex.* Fleas (Pulex).
Order 9. *Diptera.*—*Ex.* House-flies (Musca).
Order 10. *Lepidoptera.*—*Ex.* Butterflies and Moths.
Order 11. *Hymenoptera.*—*Ex.* Bees and wasps.
Order 12. *Strepsiptera.*—*Ex.* Stylops.
Order 13. *Coleoptera.* — *Ex.* Cockchafers (Melolontha), Stag-beetles (Lucanus), Weevils (Curculio).

SUB-KINGDOM V.—MOLLUSCA.

Animal soft-bodied, usually with a hard covering or shell; not exhibiting any distinct segmentation. Nervous system consisting of a single ganglion or of scattered pairs of ganglia. A distinct heart and breathing organ, or neither.

DIVISION I. MOLLUSCOIDA.—*Nervous system consisting of a single ganglion or a principal pair of ganglia. No heart, or an imperfect one.*

CLASS A. POLYZOA.—Animal always forming compound growths or colonies. No heart. The mouth of each member of the colony surrounded by a circle or crescent of ciliated tentacles. *Ex.* Sea-mat (Flustra).

CLASS B. TUNICATA.—Animal simple or compound, enclosed in a leathery or gristly case. An imperfect heart. *Ex.* Sea-squirt (Ascidia).

CLASS C. BRACHIOPODA.—Animal simple, enclosed in a bivalve shell. Mouth furnished with two long fringed processes or "arms." *Ex.* Lamp-shells (Terebratula).

DIVISION II. MOLLUSCA PROPER.—*Nervous system consisting of three principal pairs of ganglia. Heart well developed, of at least two chambers.*

CLASS D. LAMELLIBRANCHIATA.—No distinct head or teeth. Body enclosed in a bivalve shell. One or two leaf-like gills on each side of the body. *Ex.* Oyster, Mussel, Cockle.

CLASS E. GASTEROPODA.—A distinct head and toothed tongue. Shell, when present, univalve or multivalve, never bivalve. Locomotion effected by creeping about on the flattened under-surface of the body ("foot"), or by swimming by means of a fin-like modification of the same. *Ex.* Whelk, Periwinkle, Snail.

CLASS F. PTEROPODA.—Animal oceanic, swimming by means of two wing-like appendages, one on each side of the head. Size minute. *Ex.* Cleodora.

CLASS G. CEPHALOPODA.—Animal with eight or more processes or "arms" placed round the mouth. Mouth armed with jaws and a toothed tongue. Two or four plume-like gills. In front of the body a muscular tube ("funnel"), through which is expelled the water which has been used in respiration. An external shell in some, an internal skeleton in others.

Order 1. *Dibranchiata.—Ex.* Calamary (Loligo); Poulpe (Octopus); Paper Nautilus (Argonauta).

Order 2. *Tetrabranchiata.—Ex.* Pearly Nautilus; Ammonites; Orthoceras.

SUB-KINGDOM VI.—VERTEBRATA.

Body composed of a number of definite segments placed one behind the other in a longitudinal series. The main masses of the nervous system are placed upon the dorsal aspect of the body, and are shut off from the general body-cavity. The limbs (when present) are turned away from that side of the body on which the main masses of the nervous system are placed, and are never more than four in number. In most cases a backbone or "vertebral column" is present in the fully grown animal.

SECTION A. ICHTHYOPSIDA :—

CLASS I. PISCES (FISHES).—Respiration by gills; heart usually of one auricle and one ventricle; blood cold; limbs, when present, in the form of fins.

Order 1. *Pharyngobranchii.*—*Ex.* Lancelet.
Order 2. *Marsipobranchii.*—*Ex.* Lampreys and Hag-fishes.
Order 3. *Teleostei.*—*Ex.* Eels, Herrings, Cod, Flat-fishes, Salmon, and Trout.
Order 4. *Ganoidei.*—*Ex.* Bony Pike, Sturgeons.
Order 5. *Elasmobranchii.*—*Ex.* Sharks and Rays.
Order 6. *Dipnoi.*—*Ex.* Mud-fish.

CLASS II. AMPHIBIA.—Respiration at first exclusively by gills, afterwards by lungs, alone or associated with gills; skull with two condyles; limbs never converted into fins; heart of the adult composed of two auricles and one ventricle.

Order 1. *Labyrinthodontia.*—*Ex.* Labyrinthodon.
Order 2. *Ophiomorpha.*—*Ex.* Cæcilia.
Order 3. *Urodela.*—*Ex.* Newts.
Order 4. *Anoura.*—*Ex.* Frogs and Toads.

SECTION B. SAUROPSIDA :—

CLASS III. REPTILIA.—Respiration aerial, never by gills; pulmonary and systemic circulations always connected together, either within the heart itself, or in its immediate neighbourhood; blood cold; skull with one condyle; integumentary covering in the form of scales or plates, and never in the form of feathers.

Order 1. *Chelonia.*—*Ex.* Tortoises and Turtles.
Order 2. *Ophidia.*—*Ex.* Vipers, Boas, Rattlesnakes.
Order 3. *Lacertilia.*—*Ex.* Lizards, Geckos, Monitors.
Order 4. *Crocodilia.*—*Ex.* Crocodiles and Alligators.
Order 5. *Ichthyopterygia.*—*Ex.* Ichthyosaurus.
Order 6. *Sauropterygia.*—*Ex.* Plesiosaurus.
Order 7. *Pterosauria.*—*Ex.* Pterodactyle.
Order 8. *Anomodontia.*—*Ex.* Dicynodon.
Order 9. *Deinosauria.*—*Ex.* Iguanodon.
Order 10. *Theriodontia.*—*Ex.* Cynodraco.

CLASS IV. AVES (BIRDS).—Respiration aerial; lungs connected with air-sacs; heart four-chambered; blood warm; integumentary covering in the form of feathers; fore limbs converted into wings; animal oviparous; skull with one condyle.

Order 1. *Cursores* (*Runners*).—*Ex.* Ostrich, Emeu, Cassowary, Apteryx.
Order 2. *Natatores* (*Swimmers*).—*Ex.* Ducks, Geese, Penguins, Gulls, Petrels.
Order 3. *Grallatores* (*Waders*).—*Ex.* Rails, Cranes, Herons, Snipes, Curlews, Plovers.
Order 4. *Rasores* (*Scratchers*).—*Ex.* Grouse, Pheasants, Peafowl, Common Fowl, Pigeons.

Order 5. *Scansores* (*Climbers*).—*Ex.* Parrots, Cuckoos, Woodpeckers.
Order 6. *Insessores* (*Perchers*).—*Ex.* Crows, Finches, Linnets, Larks, Shrikes, Thrushes, Humming-birds, Swallows, Swifts, King-fishers.
Order 7. *Raptores* (*Birds of Prey*).—*Ex.* Owls, Hawks, Buzzards, Eagles, Vultures.
Order 8. *Saururæ.*—*Ex.* Archæopteryx.
Order 9. *Odontolcæ.*—*Ex.* Hesperornis.
Order 10. *Odontotormæ.*—*Ex.* Ichthyornis.

SECTION C. MAMMALIA :—

CLASS V. MAMMALIA.—Respiration aerial; lungs not connected with air-sacs; heart four-chambered; blood warm; integumentary covering in the form of hairs; the young nourished by milk, secreted by special glands—the mammary glands; skull with two condyles.

DIVISION A. NON-PLACENTAL MAMMALS.

Order 1. *Monotremata.*—*Ex.* Duck-mole, Echidna.
Order 2. *Marsupialia.*—*Ex.* Kangaroos, Opossums, Bandicoots, Wombats.

DIVISION B. PLACENTAL MAMMALS.

Order 3. *Edentata.*—*Ex.* Sloths, Ant-eaters, Armadillos.
Order 4. *Sirenia.*—*Ex.* Manatee, Dugong.
Order 5. *Cetacea.*—*Ex.* Whales, Dolphins.
Order 6. *Ungulata.*—*Ex.* Rhinoceros, Tapirs, Horse, Ass, Hippopotamus, Hogs, Camels, Giraffe, Deer, Antelopes, Oxen, Sheep, Goats.
Order 7. *Hyracoidea.*—*Ex.* Hyrax.
Order 8. *Proboscidea.*—*Ex.* Elephants.
Order 9. *Carnivora.*—*Ex.* Seals, Walrus, Bears, Weasels, Otters, Dogs, Wolves, Foxes, Lions, Tigers, Cats.
Order 10. *Rodentia.*—*Ex.* Hares, Rabbits, Porcupines, Beavers, Rats, Mice, Squirrels.
Order 11. *Cheiroptera.*—*Ex.* Bats and Fox-Bats.
Order 12. *Insectivora.*—*Ex.* Moles, Shrew-mice, Hedgehogs, Flying-Lemur.
Order 13. *Quadrumana.*—*Ex.* Lemurs, Spider-monkeys, Baboons, Gibbons, Orang, Chimpanzee, Gorilla.
Order 14. *Bimana.*—Man.[1]

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[1] The extinct orders of the *Dinocerata*, *Tillodontia*, and *Toxodontia* are omitted in the above enumeration of the Mammalian orders.

GLOSSARY.

ABDOMEN (Lat. *abdo*, I conceal). The posterior cavity of the body in Vertebrates and in the highest Invertebrates, containing the intestines and others of the viscera.

ABRANCHIATE (Gr. *a*, without; *bragchia*, gill). Destitute of branchiæ or gills.

ACANTHOCEPHALA (Gr. *akantha*, a thorn; *kephale*, head). A class of parasitic worms in which the head is armed with spines.

ACARINA (Gr. *akari*, a mite). A division of the *Arachnida* comprising the mites and ticks.

ACTINOZOA (Gr. *aktin*, a ray; *zoon*, animal). That division of *Cœlenterate* animals of which the Sea-anemones may be taken as the type.

AMBULACRA (Lat. *ambulacrum*, a place for walking). The perforated spaces or rows of plates in the shell of the Sea-urchins, through which the "tube-feet" are protruded.

AMPHIBIA (Gr. *amphi*, both; *bios*, life). The class of the Frogs, Toads, Newts, and the like, which have gills when young, but develop lungs when fully grown. Most of them, therefore, live indifferently on land or in water.

ANARTHROPODA (Gr. *a*, without; *arthros*, joint; *pous*, foot). The division of *Annulose* animals in which there are no jointed appendages.

ANNELIDA (a Gallicised form of *Annulata*, Lat. *annulus*, a ring). The Ringed worms (Leeches, Tube-worms, &c.)

ANNULOIDA (Lat. *annulus*, a ring; Gr. *eidos*, form). A name sometimes given to the *Echinodermata* and *Scolecida* combined.

ANNULOSA (Lat. *annulus*, a ring). The sub-kingdom of the *Anarthropoda* and *Arthropoda*.

ANOURA (Gr. *a*, without; *oura*, tail). The tail-less Amphibians, such as the Frogs and Toads.

ANTENNÆ (Lat. *antenna*, a yard-arm). The jointed horns or feelers possessed by most Articulate animals.

ANTHROPOID (Gr. *anthropos*, man; *eidos*, form). Resembling man in anatomical structure. Applied to the highest Apes.

APTEROUS (Gr. *a*, without; *pteron*, wing). Destitute of wings.

ARACHNIDA (Gr. *arachne*, a spider). A class of Articulate animals comprising the Spiders, Scorpions, Mites, and the like.

ARTHROPODA (Gr. *arthros*, a joint; *pous*, foot). The Insects, Crustaceans, and other Annulose animals, in which the body is furnished with jointed appendages.

ARTICULATA (Lat. *articulus*, a little joint). *Arthropoda*.

ARTIODACTYLA (Gr. *artios*, even; *daktulos*, a finger or toe). The hoofed Quadrupeds (*Ungulata*) with an even number of toes (two or four) to each foot.

ASTEROIDEA (Gr. *aster*, star; *eidos*, form). The Star-fishes and their allies.

AVES (Lat. *avis*, a bird). The class of the Birds.

BIMANA (Lat. *bis*, twice; *manus*, hand). The order of *Mammalia* constituted by Man alone.

BRACHIOPODA (Gr. *brachion*, arm; *pous*, foot). A class of Molluscs, with two fleshy ciliated "arms" attached to the sides of the mouth.

BRACHYURA (Gr. *brachus*, short; *oura*, tail). The tribe of Crustaceans comprising the Crabs.

BRANCHIA (Gr. *bragchia*, the gill of a fish). A breathing-organ adapted for breathing air dissolved in water.

BRANCHIATE. Possessing gills.

BYSSUS (Gr. *bussos*, flax). The silky threads by which many shell-fish moor themselves to foreign objects.

CÆCAL (Lat. *cæcus*, blind). Terminating blindly or in a closed extremity.

CALYCOPHORIDÆ (Gr. *kalux*, a cup; *phero*, I carry). An order of *Oceanic Hydrozoa* with bell-shaped swimming-organs.

CANINE (Lat. *canis*, a dog). The eye-tooth in the jaw of Mammals, so called because very well developed in Dogs.

CARNIVORA (Lat. *caro*, flesh; *voro*, I devour). An order of Mammals.

CARPUS (Gr. *karpos*, the wrist). The small bones which intervene between the forearm and hand.

CAVICORNIA (Lat. *cavus*, hollow; *cornu*, horn). The hollow-horned Ruminants, in which the horn consists of a horny sheath round a bony core.

CEPHALOPODA (Gr. *kephale*, head; *pous*, foot). The Cuttle-fishes and their allies, in which there is a series of arms ranged round the mouth.

CETACEA (Gr. *ketos*, a whale). An order of Mammals.

CHEIROPTERA (Gr. *cheir*, hand; *pteron*, wing). An order of Mammals.

CHELONIA (Gr. *chelone*, a tortoise). An order of Reptiles.

CHRYSALIS (Gr. *chrusos*, gold). The motionless pupa of Butterflies and Moths, so called because sometimes exhibiting a golden lustre.

CILIA (Lat. *cilium*, an eyelash). Microscopic hair-like filaments, which have the power of lashing backwards and forwards.

CIRRIPEDIA (Lat. *cirrus*, a curl; *pes*, foot). An order of *Crustacea* with curled jointed feet.

CLAVICLE (Lat. *clavicula*, a little key). The collar-bone.

CŒLENTERATA (Gr. *koilos*, hollow; *enteron*, intestine). The sub-kingdom comprising the *Actinozoa* and *Hydrozoa*.

CŒNOSARC (Gr. *koinos*, common; *sarx*, flesh). The common fleshy stem which unites together the separate "zoöids" of a compound *Actinozoön* or *Hydrozoön*.

COLEOPTERA (G. *koleos*, a sheath; *pteron*, wing). The order of the Beetles, in which the front wings are hardened and form protective sheaths for the hind wings.

CONDYLE (Gr. *kondulos*, a knuckle). The surface by which one bone is jointed to another. Applied especially to the surfaces by which the head is jointed to the spine.

CORACOID (Gr. *korax*, a crow; *eidos*, form). One of the bones of the shoulder-girdle in Birds, Reptiles, and Monotremes. In most Mammals it forms a mere process of the shoulder-blade, and in man its shape is something like a crow's beak; hence its name.

CRINOIDEA (Gr. *krinos*, a lily; *eidos*, form). An order of *Echinoderms* comprising forms which are usually stalked, and sometimes resemble lilies in shape.

CROCODILIA (Gr. *krokodeilos*, a crocodile). An order of Reptiles.

CRUSTACEA (Lat. *crusta*, a crust). The Crabs, Lobsters, and the like, in which the body is covered with a hard shell or crust, which is periodically shed.

CTENOID (Gr. *kteis*, a comb; *eidos*, form). Applied to certain scales of Fishes.

CTENOPHORA (Gr. *kteis*, a comb; *phero*, I bear). An order of *Actinozoa* comprising oceanic creatures which swim by means of "ctenophores," or bands of cilia arranged in comb-like plates.

CURSORES (Lat. *curro*, I run). An order of Birds.

CYCLOID (Gr. *kuklos*, a circle; *eidos*, form). Applied to certain scales of Fishes.

CYSTIC (Gr. *kustis*, a bladder). Applied to the young forms of Tapeworms (Bladder-worms).

DECAPODA (Gr. *deka*, ten; *pous*, foot). Applied to certain Crustaceans and Cuttle-fishes.

DIAPHRAGM (Gr. a partition). The "midriff," or the muscle which in *Mammalia* separates the cavity of the chest from that of the abdomen.

DIBRANCHIATA (Gr. *dis*, twice; *bragchia*, gill). The order of *Cephalopoda* with two gills.

DIGIT (Lat. *digitus*). A finger or toe.

DIGITIGRADE (Lat. *digitus*, a finger; *gradior*, I walk). Walking upon the tips of the toes.

DIPNOI (Gr. *dis*, twice; *pnoë*, breath). An order of Fishes.

DIPTERA (Gr. *dis*, twice; *pteron*, wing). An order of Insects.

DISCOPHORA (Gr. *diskos*, a quoit or round plate; *phero*, I carry). The Jelly-fishes, so called from their form.

DORSAL (Lat. *dorsum*, the back). Connected with the region of the back.

ECHINODERMATA (Gr. *echinos*, a hedgehog; *derma*, skin). The Sea-urchins, Star-fishes, and the like, most of which have spiny skins.

ECHINOIDEA (Gr. *echinos*; and *eidos*, form). The Sea-urchins.

ECTODERM (Gr. *ektos*, outside; *derma*, skin). The outer layer of the body of Cœlenterate animals.

EDENTATA (Lat. *e*, without; *dens*, tooth). An order of Mammals.

ELASMOBRANCHII (Gr. *elasma*, a thin plate; *bragchia*, gill). An order of Fishes.

ENDODERM (Gr. *endon*, within; *derma*, skin). The inner layer of the body of Cœlenterate animals.

ERRANTIA (Lat. *erro*, I wander). An order of Ringed worms (*Annelida*).

FIBULA (Lat. a brooch). The outermost of the two bones of the leg in the higher Vertebrates.

FORAMINIFERA (Lat. *foramen*, a hole; *fero*, I carry). An order of Protozoa, usually with perforated shells.

FURCULUM (Lat. diminutive of *furca*, a fork). The V-shaped bone or "merry-thought" of Birds, formed by the united clavicles.

GANOID (Gr. *ganos*, splendour; *eidos*, form). Applied to certain of the scales of Fishes.

GANOIDEI. An order of Fishes with ganoid scales.

GASTEROPODA (Gr. *gaster*, belly; *pous*, foot). A class of Molluscs in which locomotion is usually effected by creeping about on a flattened "foot."

GONOPHORE (Gr. *gonos*, offspring; *phero*, I bear). The reproductive buds of the *Hydrozoa*.

GRALLATORES (Lat. *grallæ*, stilts). The order of the Wading Birds.

GREGARINIDÆ (Lat. *gregarius*, occurring in numbers together). A class of the *Protozoa*.

HEMIPTERA (Gr. *hemi*, half; *pteron*, wing). An order of Insects.

HETEROCERCAL (Gr. *heteros*, diverse; *kerkos*, tail). Applied to the tail of Fishes when it is unequally lobed.

HETEROPODA (Gr. *heteros*, diverse; *pous*, foot). An order of Gasteropodous Molluscs.

HIRUDINEA (Lat. *hirudo*, a horse-leech). The order of the Leeches.

HOMOCERCAL (Gr. *homos*, same; *kerkos*, tail). Applied to the tail of Fishes when it is equally lobed.

HYDRA (Gr. *hudra*, a water-serpent). The generic name of the Fresh-water Polypes.

HYDROIDA (Gr. *hudra; eidos*, form). The sub-class of the Hydroid Zoophytes.

HYDROTHECA (Gr. *hudra; theke*, case). The little cups in which are contained the polypites of certain of the Hydroid Zoophytes (*Sertularida*).

HYDROZOA (Gr. *hudra; zoön*, animal). The class of Cœlenterate animals comprising creatures constructed after the type of the *Hydra*.

HYMENOPTERA (Gr. *humen*, a membrane; *pteron*, a wing). An order of Insects.

HYRACOIDEA (Gr. *hurax*, a shrew; *eidos*, form). An order of Mammals.

IMAGO (Lat. an image or apparition). The perfect Insect after it has passed through all its metamorphoses.

INCISORS (Lat. *incido*, I cut). The cutting-teeth fixed in the front of the upper jaw, and the corresponding teeth in the lower jaw of the Mammalia.

INFUSORIA (Lat. *infusum*, an infusion). A class of the *Protozoa*, so called from their frequent occurrence in organic infusions.

INSECTA (Lat. *inseco*, I cut into). The class of the true Insects.

INSECTIVORA (Lat. *insectum*, an insect; *voro*, I devour). An order of Mammals.

INVERTEBRATA (Lat. *in*, without; *vertebra*, a bone of the back). Animals without a backbone.

ISOPODA (Gr. *isos*, equal; *pous*, foot). An order of *Crustacea* comprising the Wood-lice and their allies.

LACERTILIA (Lat. *lacerta*, a lizard). An order of Reptiles.

LAMELLIBRANCHIATA (Lat. *lamella*, a plate; Gr. *bragchia*, gill). The Bivalve Shell-fish.

LARVA (Lat. a mask). The insect in its first stage after being hatched, when it is usually very unlike the adult.

LEPIDOPTERA (Gr. *lepis*, a scale; *pteron*, a wing). The order of Insects comprising the Butterflies and Moths.

LUCERNARIDA (Lat. *lucerna*, a lamp). A division of the *Hydrozoa*.

MACRURA (Gr. *makros*, long; *oura*, tail). The tribe of Crustaceans comprising the Lobsters and their allies.

MADREPORIFORM. Perforated by small holes like a Coral (or *Madrepore*).

MAMMALIA (Lat. *mamma*, the breast). The class of Vertebrate animals which suckle their young.

MARSIPOBRANCHII (Gr. *marsipos*, a pouch: *bragchia*, gill). An order of Fishes.

MARSUPIALIA (Lat. *marsupium*, a pouch). An order of Mammals.

MEDUSÆ. A group of *Hydrozoa* comprising the Jelly-fishes, so called because of the resemblance of their tentacles to the snaky hair of the Medusa.

MEDUSIFORM. Resembling a Jelly-fish in shape.

MESENTERIES (Gr. *mesos*, intermediate; *enteron*, intestine). The membrane by which the intestine is attached to the wall of the abdomen. In a restricted sense, the vertical plates which divide the body-cavity of a Sea-anemone into chambers.

METACARPUS (Gr. *meta*, after; *karpos*, wrist). The bones which form the "root of the hand," and intervene between the wrist and the fingers.

METAMORPHOSIS (Gr. *meta*, denoting change; *morphe*, shape). The changes of form which certain animals undergo in passing from their younger to their fully-developed condition.

METATARSUS (Gr. *meta*, after; *tarsos*, instep). The bones which intervene between the instep and the toes in the higher Vertebrates.

MOLARS (Lat. *mola*, a mill). The "grinders" in man; or the teeth in Mammals which are not preceded by milk-teeth.

MOLLUSCA (Lat. *mollis*, soft). The sub-kingdom comprising the true Shell-fish, the Sea-mosses, the Sea-squirts, and the Lamp-shells.

MOLLUSCOIDA (*Mollusca;* and Gr. *eidos*, form). The lower division of the sub-kingdom *Mollusca*.

MONOTREMATA (Gr. *monos*, single; *trema*, aperture). An order of Mammals.

MYRIAPODA (Gr. *murios*, countless; *pous*, foot). The class of Articulate animals comprising the Centipedes and their allies.

NATATORES (Lat. *nare*, to swim). The order of the Swimming Birds.

NEMATODA (Gr. *nema*, thread; *eidos*, form). A division of the *Scolecida*.

NEUROPTERA (Gr. *neuron*, a nerve; *pteron*, a wing). An order of Insects.

NOTOCHORD (Gr. *notos*, the back; *chordé*, a string). A cellular rod which is developed in the embryo of Vertebrates immediately beneath the spinal cord, and is usually replaced in the adult by the vertebral column.

NUDIBRANCHIATA (Lat. *nudus*, naked; Gr. *bragchia*, gill). An order of Gasteropodous Molluscs.

OCTOPODA (Gr. *okto*, eight; *pous*, foot). A tribe of Cuttle-fishes with eight arms round the head.

ODONTOPHORE (Gr. *odous*, tooth; *phero*, I carry). The "tongue" or masticating apparatus of the *Gasteropoda*, *Pteropoda*, and *Cephalopoda*.

OLIGOCHÆTA (Gr. *oligos*, few; *chaite*, bristle). The order of Annelides comprising the Earth-worms.

OPHIDIA (Gr. *ophis*, a serpent). An order of Reptiles.

OPHIOMORPHA (Gr. *ophis*, a serpent; *morphe*, sharpe). An order of *Amphibia*.

OPHIUROIDEA (Gr. *ophis*, a serpent; *oura*, tail). An order of Echinoderms (Sand-stars, &c.)

ORTHOPTERA (Gr. *orthos*, straight; *pteron*, wing). An order of Insects.

PECTORAL (Lat. *pectus*, the breast). Connected with the chest.

PEDIPALPI (Lat. *pes*, foot; *palpo*, I feel). An order of *Arachnida* (Scorpions, &c.)

PERISSODACTYLA (Gr. *perissos*, uneven; *daktulos*, finger). The Hoofed Quadrupeds (*Ungulata*) in which the toes are uneven in number (one or three).

PHALANGES (Gr. *phalanx*, a row). The small bones of the fingers and toes.

PHARYNGOBRANCHII (Gr. *pharugx*, the pharynx; *bragchia*, gill). An order of Fishes.

PHARYNX (Gr. *pharugx*). The upper part of the gullet.

PHYSOPHORIDÆ (Gr. *phusa*, bellows or air-bladder; *phero*, I carry). An order of Oceanic *Hydrozoa*.

PINNIGRADA (Lat. *pinna*, a feather; *gradior*, I walk). Applied to the Seals and Walruses, in which the limbs are converted into swimming-paddles.

PISCES (Lat. *piscis*, a fish). The class of the Fishes.

PLACOID (Gr. *plax*, a plate; *eidos*, form). Applied to certain scales of Fishes.

PLANARIDA (Gr. *plane*, wandering). A group of the *Scolecida*.

PLANTIGRADE (Lat. *planta*, the sole of the foot; *gradior*, I walk). Applying the sole of the foot to the ground in walking.

POLYPE (Gr. *polus*, many; *pous*, foot). Restricted to the single individual of a simple *Actinozoön*, or to the separate zoöids of a compound *Actinozoön*.
POLYPIDE. The separate zoöid of a *Polyzoön*.
POLYPITE. The separate zoöid of a *Hydrozoön*.
POLYZOA (Gr. *polus*, many; *zoön*, animal). The Sea-mosses and Sea-mats, a class of the *Mollusca*.
PROBOSCIDEA (Lat. *proboscis*, the snout). An order of Mammals (Elephants).
PROTOZOA (Gr. *protos*, first ; *zoön*, animal). The lowest division of the animal kingdom.
PSEUDOHÆMAL (Gr. *pseudos*, falsity, hence false; *haima*, blood). Applied to a peculiar system of vessels found in the Annelides.
PSEUDOPODIA (Gr. *pseudos*, falsity; *pous*, foot). The extemporised feet of the *Rhizopoda*.
PTEROPODA (Gr. *pteron*, wing; *pous*, foot). A class of *Mollusca*.
PULMONARY (Lat. *pulmo*, a lung). Connected with the lungs.

QUADRUMANA (Lat. *quatuor*, four; *manus*, hand). An order of Mammals (Monkeys, &c.)

RADIOLARIA (Lat. *radius*, a ray). An order of *Rhizopoda*.
RADIUS. The innermost of the two bones of the forearm of the higher Vertebrates.
RAPTORES (Lat. *rapto*, I plunder). The order of the Birds of Prey.
RASORES (Lat. *rado*, I scrape or scratch). The order of the Scratching Birds (Fowls, Pigeons, &c.)
REPTILIA (Lat. *repto*, I crawl). The class of Vertebrates comprising the true Reptiles.
RHIZOPODA (Gr. *rhiza*, root; *pous*, foot). A division of the *Protozoa*.
RODENTIA (Lat. *rodo*, I gnaw). An order of Mammals.
ROTIFERA (Lat. *rota*, a wheel; *fero*, I carry). A class of the *Scolecida* (Wheel-animalcules).
RUMINANTIA (Lat. *ruminor*, I chew the cud). A group of the Hoofed Quadrupeds.

SARCODE (Gr. *sarx*, flesh; *eidos*, form). The jelly-like substance composing the body in the *Protozoa*.
SCANSORES (Lat. *scando*, I climb). The order of the Climbing Birds (Parrots, &c.)
SCOLECIDA (Gr. *skolex*, a worm). A division of the *Annulosa*.
SERTULARIDA (Lat. *sertum*, a wreath). An order of the Hydroid Zoophytes.
SIPHONOPHORA (Gr. *siphon*, a tube; *phero*, I carry). A sub-class of the *Hydrozoa*.
SIRENIA (Gr. *seiren*, a mermaid). An order of Mammals (Dugongs and Manatees).
SOMATIC (Gr. *soma*, body). Connected with the body.
SPICULA (Lat. *spiculum*, a point). Pointed needle-shaped bodies.
SPONGIDA (Gr. *spoggos*, a sponge). A division of the *Protozoa* (Sponges).
STERNUM (Gr. *sternon*). The breast-bone.

TÆNIADA (Gr. *tainia*, a ribbon). The order of the Tape-worms.
TARSUS (Gr. *tarsos*, the flat of the foot). The small bones which form the ankle.
TELEOSTEI (Gr. *teleios*, perfect; *osteon*, bone). The order of the Bony Fishes.
TEST (Lat. *testa*, a shell). The shell of the Molluscs, Sea-urchins, &c.

TETRABRANCHIATA (Gr. *tetra*, four; *bragchia*, gill). The order of *Cephalopoda* with four gills.

THORAX (Gr. a breast-plate). The chest.

TIBIA (Lat. a flute). The shin-bone, or innermost of the two bones of the leg in the higher Vertebrates.

TRACHEA (Gr. *tracheia*, the rough windpipe). In air-breathing Vertebrates, the tube which conveys the air to the lungs. In Insects, Myriapods, and Spiders, the air-tubes which ramify through the body.

TREMATODA (Gr. *trema*, a pore or hole). An order of the *Scolecida*.

TUBICOLA (Lat. *tuba*, a tube; *colo*, I inhabit). An order of the *Annelida* (Tube-worms).

TUNICATA (Lat. *tunica*, a cloak). The Sea-squirts, a class of the Mollusca.

ULNA (Gr. *olené*, the elbow). The outermost of the two bones of the forearm in the higher Vertebrates.

UMBO (Lat. the boss of a shield). The beak of a bivalve shell.

UNGULATA (Lat. *ungula*, a hoof). The order of the Mammals comprising the Hoofed Quadrupeds.

URODELA (Gr. *oura*, tail; *delos*, visible). The order of the Tailed Amphibians (Newts, &c.)

VENTRAL (Lat. *venter*, the belly). Relating to the lower surface of the body.

VERTEBRA (Lat. *verto*, I turn). One of the bones of the spinal column or backbone.

VERTEBRATA. The sub-kingdom comprising animals, almost all of which have a more or less well-developed vertebral column.

XIPHOSURA (Gr. *xiphos*, sword; *oura*, tail). An order of the *Crustacea* (King-Crabs).

ZOÖID (Gr. *zoön*, animal; *eidos*, form). The more or less completely independent being, produced by budding or fission from a primitive organism.

ZOOPHYTE (Gr. *zoön*, animal; *phuton*, plant). Loosely applied to many plant-like animals, such as Sponges, Corals, Sea-anemones, Sea-firs, Sea-mats, &c.

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